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1929-1930.

The Authors of Papers are alone responsible for the statements
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CORRIGENDA.

headings, pages 3-85 inclusive—
for Vol. XVI., 1930-31, *read* Vol. XVI., 1929-30.

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CORRIGENDA.

JOURNAL ROY. SOC., WESTERN AUSTRALIA.

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"A description of two New Species of Anostracan Phyllopoda from Western Australia," by Dorothy F. Milner, B.Sc.

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26	13	*for* Mirabilis *read* mirabilis.
27	49	*for* basil *read* basal.
28	32	*for* Pl. II., *read* Pl. V.
29	bet. 25 and 26	*insert* **Branchinella wellardi**, sp. nov. (Pl. VI.)
31	43	*for* Daday, de Des *read* Daday de Dées.
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Anderson, Joseph, 9 *Mitchell Street, Mt. Lawley.*

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Shelton, Miss K., 20 *Kershaw Street, Subiaco.*
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Steedman, H., 25 *Fremantle Road, Victoria Park.*
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Stokle, W., 39 *Gloster Street, Subiaco.*
Southern, Mrs. Mary E., 623 *Hay Street, Perth.*
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Bourne, W. G., 23 *Angelo Street, South Perth.*

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Hobson, R. A., B.Sc., *The University of W.A., Perth.*
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Proceedings

of

The Royal Society of Western Australia.

Session 1929-30.

ANNUAL REPORT OF THE COUNCIL

FOR

THE YEAR ENDING 30th JUNE, 1930.

Ladies and Gentlemen,

Your Council begs to submit the following report for the year ending June 30th, 1930 :—

Membership.

There are 217 members on the roll, of whom 10 are honorary members, 6 corresponding members, 130 ordinary members, 67 associate members and 4 student members. During the year 10 ordinary members and 7 associate members have been elected, while 4 ordinary members and 2 associate members have resigned. The names of 6 ordinary members and 3 associates have been removed in accordance with Rule 13. Two corresponding members having returned to Western Australia have been transferred to their original membership as from the end of the financial year in accordance with the rule governing corresponding membership.

Mr. A. Gibb Maitland was elected an honorary member of the Society in accordance with the rule permitting this honour to be conferred upon distinguished workers in science. Mr. Maitland has been responsible for many valuable contributions to the geology of Western Australia. He has twice held the office of President and has also carried out the duties of Editor for a number of years.

We regret to report the loss, by death, of a foundation member of the Society, Dr. A. J. H. Saw.

Council.

Eleven ordinary meetings of the Council were held during the year.

In October Dr. Teakle found it necessary to temporarily relinquish the duties of Treasurer while engaged in official duties in a remote portion of the State. He resumed duty as Treasurer in March. During this period Mr. F. E. Allum, I.S.O., carried out the duties of Treasurer, and the Council desires to record its appreciation of his valued assistance.

Finance.

The statement of the Society's Income and Expenditure during the 1929–30 Session, which will be found appended, may be summarised as follows :—

During the year the total receipts on account of income, which includes the subsidy granted by the Government, amounted to £286 5s. 4d., being £1

14s. 8d. less than that received during the previous session. On the other hand, the current expenditure of the Society's year amounted to £234 16s. 7d. at the time of the preparation of the Balance Sheet.

The excess of receipts over expenditure for the year amounted to £51 8s. 9d. As an additional sum of £43 0s. 7d. has already been incurred for printing and binding, but no accounts submitted for payment, the actual excess of receipts amounts to £8 8s. 2d.

The grant received from the Treasury during the year was at the rate of £100 per annum, as in preceding years, and the Council wishes to express its thanks to the Government for the subsidy. Without the aid of the Government grant the publication of papers in the Journal would have to be seriously curtailed. At present it is possible for the Council to assure Western Australian scientific workers reasonable facilities for publication of original contributions to science.

PUBLICATIONS.

Volume XV. containing the proceedings and transactions for the year 1928–29 has been completed and issued to members and distributed in accordance with the exchange list. Volume XVI. containing the proceedings for the year 1929–30 is well in hand. All papers contributed to the Society during the year are with the printer. The volume should be completed and issued to members early in the forthcoming session.

The Council has to acknowledge its indebtedness to Mr. W. E. Shelton, Vice-President, for undertaking the task of editing Volume XVI.

Applications were invited for the position of Editor, and Mr. B. L. Southern has been appointed to the position as from the commencement of the 1930–31 Session.

RULES.

During the year the Council has devoted a considerable proportion of its time to the consideration of the Rules and as a result, various amendments have been passed, and the Rules in their present form will be included in Vol. XVI. These Rules have been adopted as the Rules of the Society as from November 12th, 1929.

CONFERENCE OF ROYAL SOCIETIES.

The Royal Society of Victoria submitted a proposal for the amalgamation of the Royal Societies in the various States of Australia, to form either a single Royal Society of Australia, or a federation of State Royal Societies. An advantage of this proposal would be the issue of publications dealing with specialised branches of science.

It was considered by the Council that such a federation would not be in the best interests of this Society at the present time. As, however, the majority of the Royal Societies considered the project worthy of discussion, advantage was taken of the meeting of the Australasian Association for the Advancement of Science in Brisbane, in May of this year, for a conference to be called during the progress of that meeting. Professor N. T. M. Wilsmore attended that meeting as a delegate of this Society.

Australasian Association for the Advancement of Science.

Professors E. deC. Clarke and N. T. M. Wilsmore acted as delegates of this Society to the Council of the A.A.A.S.

Museum of Natural History at Canberra.

The Prime Minister's Department invited the Royal Society to submit its views concerning the proposal to establish a Museum of Natural History at Canberra. A special committee considered the details of the proposal and submitted the following report which was adopted by the Council and forwarded to the Prime Minister's Department :—

1. The Commonwealth Museum proposals, taken generally, are worthy of adoption, and a commencement should be made as early as possible.
2. That a Department of Entomology be founded and that it be independent of the Zoological Department.
3. That each department of the Museum be under the complete control of its own Chief Officer, and that it have a separate budget. The Chief Officers shall be under the control of a Director, who shall be responsible to a Board.
4. The Board should be so constituted that scientific interests are adequately represented. The Board should include an entomologist and a botanist. The Board should be larger than proposed, and should select from its members a smaller executive.

Co-operation with Pastoralists in Protection of the Wild Turkey.

As the result of a letter from the Pastoralists' Association asking for co-operation, a sub-committee consisting of Mr. E. W. Bennett, Col. E. A. LeSouef and Mr. L. Glauert (convener) was appointed to consider, (i) the advisability of recommending the extension of the protection of the "Wild Turkey" (Australian Bustard), and (ii) the question whether any other useful bird (or birds) showed signs of verging upon extinction. No formal meetings were held, but conversations with the Chief Inspector of Fisheries yielded valuable information, and it is pleasing to report that the Wild Turkey is now protected throughout the State during the breeding season.

Annual Conversazione.

The annual Conversazione of the Society was held in the Town Hall, Perth, on Wednesday, June 18th. His Excellency the Governor, Sir William Campion, K.C.M.G., Vice-Patron of the Society, introduced the lecturer, Professor A. D. Ross, who took as his subject, "Some recent applications of Physical Science in Western Australia."

Exhibits illustrating some of the scientific investigations in this State were displayed by members, as follows :—

Agriculture.—Wheat Improvement by Cross Breeding and Selection—I. Thomas and N. D. Davenport, B.Sc. (Ag.)

Types of Western Australian Wool—H. McCallum.

The Western Australian Dairy Industry—G. K. Baron-Hay, B.Sc. (Ag.)

The Honey Industry of Western Australia—H. Willoughby Lance.

Apparatus used for Cleaning and Grading Tobacco Seed grown in Western Australia—A. R. Clifton and H. G. Elliott, Dip. Ag.

Bacteriology.—The Bacterial Control of Milk—Miss E. A. Newton.

Botany.—Recently Described Western Australian Plants—C. A. Gardner.

Native Flora: Banksia Cones, etc.—H. Steedman.

Chemistry.—The Mechanical Analysis of Soils—B. L. Southern, A.A.C.I.

The Soil Alkali Problem of Western Australia—L. J. H. Teakle, B.Sc. (Ag.), Ph.D.; G. H. Burvill, B.Sc. (Ag.); L. W. Samuels, B.Sc.

The Refining of Precious Metals—G. Spencer Compton, B.Sc., A.I.M.M., A.A.C.I.

Entomology.—The Entomological Investigations of the Entomological Branch of the Department of Agriculture—L. J. Newman, F.E.S.

Geology.—Peg Model of the Eradu Coal Bores—The Geological Survey Staff.

Mineralogy.—Optical Methods used in the Examination of Minerals—E. S. Simpson, D.Sc., B.E., F.A.C.I. and D. G. Murray, A.A.C.I.

Natural History.—Educational Economic and Scientific Phases of Museum Work—The Trustees of the Museum.

Physics.—Physical Apparatus—A. D. Ross, M A., D.Sc., F.Inst.P.

Physiology.—The Application of the Theory of Balance to Disturbances in the Action of the Heart—A. Webster, M.D.

Pathological Specimens—E. J. T. Thompson, M.A., B.Sc., M.B., Ch.B.

Plant Pathology.—Physiological Defects of Apples—W. M. Carne, F.L.S.

Certain Plant Diseases and Nitrogen Fixing Bacteria, being investigated by the Plant Pathology Branch of the Department of Agriculture—H. A. Pittman, B.Sc. (Ag.), and H. G. Elliott, Dip. Ag.

Veterinary Pathology.—Animal Health Research: "Braxy-like Disease, W.A."—H. W. Bennetts, M.V.Sc.

The Council desires to thank Professor Ross and the members who contributed exhibits, as well as the members of the Ladies' Committee who by their valued and willing help contributed largely to the success of the function.

GENERAL.

The following reports are appended:—

1. Treasurer's Report.
2. Librarians' Report.
3. Excursion Committee's Report.

N. T. M. WILSMORE,
Vice-President.

W. E. SHELTON,
L. W. PHILLIPS,
Joint Secretaries.

July 1st, 1930.

ROYAL SOCIETY OF WESTERN AUSTRALIA.

YEAR 1929–30.

Treasurer's Annual Report of Receipts and Expenditure, 1st July, 1929, to 1st July, 1930.

RECEIPTS.

	£ s. d.	£ s. d.
Balance, July 1st, 1929—		
Medal Fund	22 7 3	
General Fund	63 5 7	
Endowment Fund	105 0 0	
		190 12 10
Subscriptions—		
1925–26	2 12 6	
1926–27	4 4 0	
1927–28	9 9 0	
1928–29	20 9 6	
1929–30	119 14 0	
1930–31	6 6 0	
Students	1 5 0	
		164 0 0
Government Grant, June, 1929–June, 1930		108 6 7
Sale of Publications		1 17 0
Exchange on Cheques		0 1 0
Interest on Endowment		5 0 0
Interest on Current Account		7 0 9
Total		£476 18 2

EXPENDITURE.

	£ s. d.	£ s. d.
Printing—		
Part Vol. XV.	115 18 10	
Miscellaneous	10 8 10	
		126 7 8
Museum Trustees Fees	...	9 7 0
Cartage Expenses	...	1 14 6
Library—Book-binding	...	15 1 0
Rent—Post Office Box	...	3 0 0
Lecture Expenses	...	2 2 0
Conversazione, 1930	...	39 7 0
Petty Cash	...	27 17 5
Balance in Bank—		
Medal Fund	22 7 3	
General Fund	109 14 4	
Endowment Fund	120 0 0	
		252 1 7
Total		£476 18 2

Examined and found correct—

P. M. BONNERUP,
R. E. GATHERER, } Auditors.

NOTE – At the time of preparation of this Balance Sheet the following expenditure had been incurred, but no accounts had been presented for payment :– Printing : Part of Vol. XVI., £34 5s. 7d. ; Library, Binding, £8 15s. 0d.—Total £43 0s. 7d. This leaves a real credit in the General Fund amounting to £66 13s. 9d.

L. J. H. TEAKLE, Hon Treasurer.

REPORT OF THE LIBRARIANS FOR 1929–30.

1. DONATIONS.—During the year the Library has been enriched by another valuable donation received from Mr. A. Gibb Maitland, one of the Society's past Presidents.

2. EXCHANGE LIST.—The following Societies, Institutions, and Universities have been added to the exchange list, bringing the total up to 127. Particulars of the exchanges in operation are given in the table below :—

South-West Africa, Scientific Society, Windhoek, S.W.A.

The Patent Office, Library, London.

La Sociedade Brotoriana, Coimbra, Portugal.

The University of Central Asia, Tashkent, U.S.S.R.

The State University, Voronezh, U.S.S.R.

Das Landwirtschaftliche Institut, Krasnodar, U.S.S.R.

The Ukrainian Botanical Society, Kiev, U.S.S.R.

Taihoku Imperial University, Formosa, Japan.

Vanderbilt Oceanographic Museum, Huntington, Long Island, N.Y., U.S.A.

University of Washington Library, Seattle, Washington, U.S.A.

Analysis of Exchange List.

	Scientific Societies.	Government Departments.	Universities.	Museums Libraries.	Total.
Australia	9	12	4	12	37
New Zealand ...	1	...	1	1	3
South Africa	3	1	...	2	6
India	1	2	...	1	4
Canada	1	1	...	...	2
United Kingdom ...	5	2	1	5	13
Europe	7	1	9	10	27
Asia	...	1	2	...	3
U.S.A.	2	1	12	13	28
South America ...	2	2	...	...	4
	31	23	29	44	127

3. PURCHASES.—A copy of the Catalogue of Scientific and Technical Literature published by the C.S.I.R. was purchased.

4. PUBLICATIONS.—Volume XV., 1928–29, has been received from the printer and has been distributed to members. Use will be made of the International Exchange Service to forward the Journal to those countries which are co-operating in this useful and money-saving organisation.

5. BINDING.—Approximately £25 has been spent in binding. Further considerable sums will have to be set aside in the new year, as many valuable publications are deteriorating.

L. GLAUERT
W. E. CAMPION } Hon. Librarians.

REPORT OF EXCURSIONS COMMITTEE.

During the 1929-1930 session, two field excursions of exceptional value were made by car to areas usually difficult of access.

The first, led by Professor E. deC. Clarke, visited the Gorge by which the Swan River makes its way to the coastal plain. The region, which for some time has been investigated by students of the Department of Geology of the University of Western Australia, has many features of physiographic interest, and further study may discover evidence as to the origin of laterite.

The second was to the Jimperding Valley, near Toodyay, and Dr. E. S. Simpson filled the post of leader. Besides explaining matters of interest, Dr. Simpson enabled members to collect a fine suite of mineral and rock specimens, which included excellent samples of chiastolite and fuchsite. It was pointed out that the course of the stream was almost certainly due to the faulting down of softer ancient sediments into the harder granites.

W. E. SHELTON,
Joint Hon. Secretary.

ABSTRACT OF PROCEEDINGS, 1929-30.

13TH AUGUST, 1929.

Paper.—"Aboriginal Rock Painting in North-West Australia" by the Rev. J. R. B. Love (communicated by Dr. E. J. T. Thompson).

Address.—"A Visit to the Dutch East Indies," by Professor N. T. M. Wilsmore.

10TH SEPTEMBER, 1929.

Report.—The final report of the Salinity in Soils Committee was tabled and explained by Professor N. T. M. Wilsmore.

Address.—Dr. R. J. Tillyard, Chief of the Division of Economic Entomology of the C.S.I.R. delivered an address on "The Development of Commonwealth Entomological Research."

Royal Society's Gold Medal.—A replica in tin was presented to Miss Enid Allum, the designer of the reverse side.

8TH OCTOBER, 1929.

Protection of Insectivorous Birds.—A Committee was appointed to cooperate with the Pastoralists' Association in an endeavour to obtain adequate protection for the Australian Bustard and other useful indigenous birds.

Rule Revision.—The revision of the Rules of the Society was commenced.

Lecture.—"The Braxy-like Disease of Sheep in Western Australia," by H. W. Bennetts,

Exhibits.—1. A topographical model of the Swan Gorge Area, together with contour maps and photographs, by Professor E. deC. Clarke.

2. Notes on the Petrology of the Swan Gorge Area, by Mr. Fletcher.

3. Mica schist with enclosed spinel grains and crystals, from Gillingarra, by Dr. E. S. Simpson.

4. Paintings of Australian Flora, by Mr. H. Steedman.

12TH NOVEMBER, 1929.

Rule Revision.—The revision of the Rules of the Society was completed.

Exhibits.—1. Chiastolite, Fuchsite and Beryl from the Jimperding Area, by Dr. E. S. Simpson.

2. Thorotungstite from Malaya and "Lechatelierite" or fulgurites from coast sand-hills of N.S.W., by Dr. E. S. Simpson.

3. Endeavour spider crab and a sponge crab, obtained by the trawler Bonthorpe, by Mr. L. Glauert.

4. Belemnites from Geraldton district, by Mr. L. Glauert.

5. Model of Albany Pitcher Plant (Cephalotus folicularis), by Mr. Lipfert.

6. Diamond drill borings from Big Bell Mine at Coodardie, and a device for measuring the inclination of the bore at depth, by Mr. R. C. Wilson.

7. A maize seedling with primary root exhibiting negative geotropism, by Mr. W. E. Shelton.

8. Banded jasper from Marble Bar together with South American boleros, by Mr. W. Catton Grasby.

11th March, 1930.

Papers.—1. "Contribution No. 6 to the Fauna of Rottnest Island. Notes on Neuroptera," by Mr. W. H. Mathews, and communicated by Mr. L. Glauert.

2. "The Reactions of Western Australian Soils," by Dr. L. J. H. Teakle and Mr. L. W. Samuel.

Exhibits.—1. Setonyx brachyurus, the Rottnest Wallaby or Quokka, by Mr. L. Glauert.

2. Carcharinus gangeticus, a sea shark caught in the Swan River at Crawley in February, 1930, by Mr. L. Glauert.

3. Notoplax subvirides, Chiton (Rhyssoplax) tricostalis and Chiton (Rhyssoplax) geraldtonensis, chitons recorded for the first time from Rottnest, by Mr. L. Glauert.

4. Nostoc, lichens, ostracod carapaces and cup like structures, probably fruiting bodies of a cup fungus, all found in or around the lake which was formed 13½ miles west of Forrest after the recent phenomenal rains. Miss E. R. L. Reed.

5. Cephalotus folicularis, the Albany pitcher plant. A flowering specimen was exhibited by Mr. Lipfert.

6. Celluloid model of a long-tailed lizard, by Mr. L. Lipfert.

7. A banksia of unusual habit, by Mr. Shields. (Inflorescences and leaves rose vertically from a stem lying horizontally on the ground).

8th April, 1930.

Brisbane Meeting of the A.A.A.S.—Professors N. T. M. Wilsmore and E. deC. Clarke were appointed delegates to represent the Society at the meeting of the A.A.A.S., and at a conference of Royal Societies of Australia, convened to consider the federation of Australian Royal Societies.

Papers.—1. "Notes on a Collection of Bees from Western Australia," by T. Rayment (communicated by Mr. L. Glauert).

2. "Contributions to the Mineralogy of Western Australia, series V.," by Dr. E. S. Simpson.

3. "Zebra Rock," from the East Kimberley, by Mr. R. A. Hobson (communicated by Professor E. deC. Clarke).

Exhibits.— 1. A series of rock specimens and fossils associated with the Gingin chalk, but obtained at Murchison House Station, 200 miles north of any previously recorded chalk. Included in the series were Belemnites, not previously found nearer than 200 miles to the north. The specimens were exhibited and explained by Mr. L. Glauert.

2. Mr. Steedman showed flowering specimens of Eucalypt caesia and E. erythrocorys and also a portion of a plant of a Duboisia species.

6TH MAY, 1930.

Address.—Professor Prescott, Chief of the Soils Division, Council for Scientific and Industrial Research, delivered an illustrated address on "Scientific Principles of Soil Classification."

Exhibits.—1. Flowering specimens of Stenocarpus Cunninghamii and Crotalaria laburnifolia, by Mr. Steedman.

2. Illustrations depicting the taking of X-ray photographs of the whole human body. Films and screens used were 7ft. long and 20ins. wide. The photographs were taken in Java. Exhibited by Professor N. T. M. Wilsmore.

10TH JUNE, 1930.

Papers.—1. "Constitution of a Copper Telluride from the Kalgurli G.M., Kalgoorlie," by Mr. D. G. Murray.

2. "The Laboratory Examination of Soil," by Mr. B. L. Southern.

Exhibit.—A Paw-Paw fruit grown at South Perth, by Dr. E. S. Simpson, from seed obtained in Java.

JOURNAL
OF
THE ROYAL SOCIETY
OF
WESTERN AUSTRALIA.
VOL. XVI.

I.—ROCK PAINTINGS OF THE WORRORA AND THEIR MYTHOLOGICAL INTERPRETATION.

(With Four Plates, i., ii., iii., and iv., and 14 Figures.)

By
J. A. B. LOVE, B.A., M.C., D.C.M.

(*Read* 13*th August*, 1929. *Published* 24*th July*, 1930.)

Discovery.

As early as 1838, Captain (later, Sir George) Grey, during his journey of discovery from Brunswick Bay to the Glenelg River, found several rock paintings, of which he has given us accounts in his journal, with drawings.

Grey remarks that some of the pictures obviously represented animals found in the country and that some of the designs had no meaning to the uninitiated. But the most remarkable feature of these rock painting was the frequent occurrence of a human form, in every case depicted without mouth. These human pictures, Grey surmised, from the mild expressions of their countenances, to represent females. In this surmise he was mistaken.

Territory of Worrora.

The tribe with whom I am at present in contact are the Worróra, who inhabit the country roughly between the Glenelg and Prince Regent Rivers, extending down the coast to the mouth of the Walcott Inlet, and including in their territory a strip of country on the north bank of the Prince Regent River, from Mt. Trafalgar to near, but not including, Mt. York. (Plate I.)

Locality of Paintings.

The country of the Worróra people is very rugged. The hills are mostly of a basaltic formation with a quartzite capping that rises sheer above the underlying basaltic rock. Where the overlying quartzite and the basaltic rocks meet there is a breakaway often leaving a narrow cave, extending along the line of the meeting of the two formations, for twenty or thirty yards, usually about six to ten feet in depth and about the same in height. Most of the rock paintings are in these shallow caves and only to be reached

by stiff climbing. Two very important rock paintings, however, occur in a different position. On the east of the Prince Regent River there occur isolated sandstone boulders standing on small sandy flats. These boulders are sometimes weathered away, leaving a fairly extensive cave on one side. Two of these rocks, Puróolba and Nyimúndum, have each a very fine collection of paintings. The rock paintings, for reasons which will appear, are numerous in the Worróra territory and are thoroughly known to all the Worróra.

Colour and Methods Used.

In every picture that I have seen the colours are produced by red and yellow ochre, white clay and black charcoal. Grey states that he found a blue pigment in some of the cave paintings, and in his journal gives a brilliant blue to some of his drawings. Throughout Grey shows some tendency to improve on his originals in drawing, and I can only believe that he has unconsciously exaggerated his impressions in giving such a blue to any picture as appears in the illustrations to his journal. In one case a figure appeared to me to have a bluish colour, but closer inspection led me to think that it was rather a greyish black, due to some admixture of ashes with the charcoal used. I am not acquainted with any blue pigment used by the aboriginals of this country. During certain of the ceremonies now carried out, the men's bodies are decorated with marks similar to those on the rock paintings, from which it may be legitimately inferred that the rock paintings have been executed in the same way. Red and yellow ochre and charcoal are ground into a powder on a flat stone.

For colouring a large surface the palm of the hand is used. The palm is wetted, rubbed on the powdered pigment and then rubbed over the surface to be coloured.

Broad lines are drawn with a wetted finger dipped in the powder. Lines and dots are made with a pencil of a grass stem, on the end of which is stuck a lump of wet clay or ochre and wetted in the mouth as required.

Large white splashes are blown from the mouth, which has been filled with a mixture of clay and water.

Plain white surfaces are made by rubbing with dry powdered clay, preferably on a surface that has been previously greased with kangaroo fat.

Interpretation of Pictures.

Every aboriginal man of this locality will unhesitatingly say what every picture represents, and, in cases where there does not appear to the European eye to be any obvious connection between the picture and its meaning, different men, questioned separately, have unhesitatingly given the same meaning.

(a) The Human Figure. When I first saw one of these human figures I asked, "Who is this?" and get the reply, "Wónjuna," I have to correct the impression that I first received, viz., that Wónjuna is an individual proper name. ("Transactions of the Royal Society of South Australia," Vol. XII., 1917. "Notes on the Worróra Tribe.")

All the human figures in the rock paintings are called by the Worróra, "Wónjuna," but the Wónjuna in each locality has in addition his own

proper name. Thus the Wónjuna at Woorrwái is named Wumúnngu; the Wónjuna at Paléed Paléera is named Churumáhda; the Wónjuna at Piríallu is named Punúllgurra; the Wónjuna at Malúdum is named Ngamaráhleh.

According to the Worróra mythology the Wónjuna were the first men. Before the earth had received any physical features a Wójuna appeared in a certain locality; he came from the wind, wandered over the earth making hills, rocks, waterholes, outstanding features of the coast, etc., and finally went to earth in a spot where the picture remained behind him. Here his spirit for ever abides and, wherever a Wónjuna's picture is, there the Wónjuna continues to send down the rain. All the Wónjuna were men. The creation of the physical features of the earth, however, was not their sole prerogative. This distinction they shared with certain beasts, such as the kangaroo, the rock-python, the "flying opossum," all of which beasts finally went to earth at some spot now regarded as the abiding place of the spirit of that creating beast. These spirit-places belonging to beasts are not picture caves, but remarkable natural features of the land, with which I hope to deal in a future paper. The picture caves belong to the Wónjuna alone; the human figures are all Wónjuna; only the Wónjuna now exercise the beneficient work of sending down the rain on the land.

A place where the spirit is one of the original creating men or beasts is supposed to abide is called Woonggúru. This is the neuter form of a noun and is applied to a picture cave or to one of the striking natural features associated with the wanderings of a mythological beast. The masculine form of the noun is Woonggúri. The word Woonggúri includes Wónjuna and is almost equivalent to Wónjuna. Woonggúri is, I think, the descriptive name and Wónjuna the collective proper name. The nearest translation I can give is to say that Woonggúru is "ancestral spirit place," while Woonggúri is "ancestral spirit male being."

A feminine form of the word occurs, viz., Woonggúja. This, most remarkably, is the name of the rock-python, a huge snake that inhabits this country. Woonggúja is the present name of the rock-python and also the name of the primaeval feminine counterpart of Wónjuna. The part played by this snake in Worróra mythology is truly astonishing. She ranks second only to Wónjuna in the number of natural features and legends attributed to her. To discuss Wonggúja fully would go outside the scope of this paper. Here it may be said that the rock-python created a very large number of the physical features of the country, and wherever a place name is a feminine word, enquiry reveals that it is connected with the rock-python, *e.g.*, Nyimri = Her Head, *i.e.* Woonggúja's Head; Njalím = Her Lip, *i.e.* Woonggúja's Lip; again, always when Woonggúja's name occurred and I questioned who she was, I got the reply that she was, or is, the snake. In one cave, that named Paléed Paléera, there is a full-size picture of Woonggúja.

Once, in my hearing, the feminine form of the name Wónjuna, viz., Wónjuninya, occurred. When I immediately caught up the word and questioned as to who Wónjuninya was, I at first received the reply, "Woonggúja" (the rock-python). On pressing the question I was emphatically assured that Wónjuna were all men (eja), but when I went on to ask if Wónjuninya were a woman, I got uncertain replies. To our minds if Wónjuna were a man, then Wónjuninya must have been a woman; but

the Worróra man does not argue things out to a logical conclusion. His tradition tells him that the man did certain things, also that the rock-python did certain things. To connect up all these traditions never enters his head.

The Worróra believe that the man conceives the spirit of a child in a dream. This child comes to him in a dream at a Woonggúru and is from the original mythological being who is supposed to abide at the place where he went to earth. The man puts the child in the woman, and when the child is born it is named by the father with the name of the Woonggúru where he conceived it. Every child, boy or girl, has a Woonggúru, that might be called the birth-place name, or conception-place name. Some retain their Woonggúru name throughout life as the name by which they are commonly known. Others become known by one or other of the several names which all get as they grow older. Thus it will be seen that the Wónjuna, the human figures of the cave paintings, are not the sole progenitors of the present race, any more than they are regarded as the sole creators of the physical features of the land, but share their distinction also with some of the beasts.

(b) Other Pictures. I have dealt at length with the human pictures, as these are of such prime importance in Worróra belief. I shall return to them in comparing with similar pictures found in North Africa. As well as the human figures are many representations of kangaroos, eagles, fish, edible plants and edible parts of animals. Some of these designs are portraits and are often quite spirited attempts to portray animals. At Puróolba is a quite good attempt at depicting a spray of eucalyptus blossom as the source of wild honey. An object that recurs not infrequently, and that appears meaningless till explained, is the liver of a stingray, a favourite article of food. When explained as the liver it is seen to be quite a fair picture of a liver. So also with some of the edible roots.

But quite a number of the pictures are conventional representations of some article of food, or some part of the body, which do not, to the European eye, bear any resemblance to the object represented.

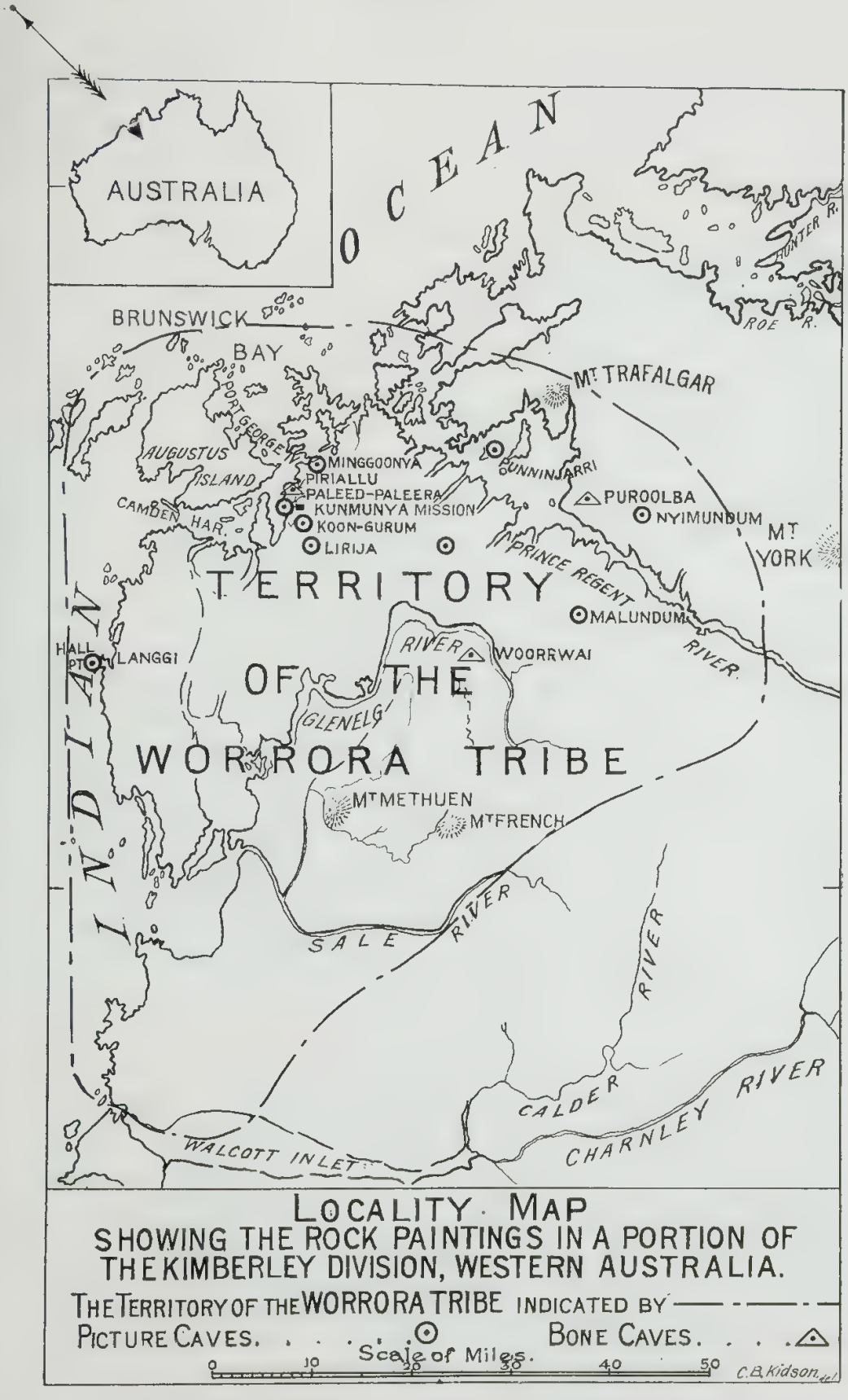
Almost all the pictures, except those of Wónjuna, represent some article of food. The most pronounced object in any of the caves is usually a picture, or many pictures, of some animal, fish, root, plant, fruit, that abounds in that particular locality. One man declared to me that everything eaten is in some cave. This is considerably an exaggeration, as there are a number of edible articles that I have not seen in any picture cave; but I have no doubt that the Worróra think that all food objects are represented somewhere.

The belief is that wherever the picture of an object of food is preserved in a picture cave, there that object will continue to flourish and increase. This explains the thought that every edible thing is depicted in a cave somewhere. This also explains the frequency of the picture caves.

I attach a sketch map of the Worróra country (Plate I.) showing all the positions of picture caves with which I am at present acquainted. It will be seen that a picture cave occurs every five miles or so.

So the whole purpose of these picture caves can be summed up in one sentence: they are to insure the food supply of the present generation.

PLATE I.



The Territory of the Worrora Tribe, Kimberley Division, W.A.

The Wónjuna cause the rain to fall wherever their pictures remain, and the food animals and plants increase wherever they are represented in pictures.

Each picture rock or cave, in addition to its local name (*i.e.*, the name of that particular spot), is called by the name of the most conspicuous object among the pictures. Thus Puróolba is known as Aianúngga (wild honey) place, Nyimúndum is known as the Warárhninya (wedge-tailed eagle) place, etc.

Certain of the picture caves are the final repositories of men's bones. There are three such within my present knowledge, Piriállu, near Port George 4th; Puróolba, near Mt. Trafalgar; and Woorwái or Arnu, near the middle of the Glenelg River. These are approximately at the furthest confines of the Worróra territory from each other. These bone-caves are known as Púnja-ngúrrim, *i.e.*, skull-places. When the final ceremonies in connection with the death of a man are completed and his bones bleached, usually about a year after death, his bones are taken to the Púnja-ngúrrim in the district to which he belongs by birth. Men will meet from very long distances to collect the bones from the bleaching platform and carry them to the bone-cave. At the bone-cave the bones are either buried by the cave, or the parcel of "paper-bark" (Ti-tree, melaleuca) is deposited in the deepest recess of the cave with a few stones roughly thrown on it. As the bark decays the bones roll about the cave and receive no further respect. In every case the bones are painted with red ochre.

It has several times been explained to me that the Ingálnj (spirit or ghost, or shadow) of the dead man keeps guard over the pictures. All men's bones are not now taken to a púnja-ngúrrim. Sometimes the bleached bones are taken by the relative of a dead man and deposited by him in a secret place, of which he tells no one. A few years ago the bones at Piriállu were removed by a white man who was collecting aboriginal information. Since then no bones have been put at that cave. Whether the present custom of hiding some of the men's bones is a consequence of the desecration of Piriállu, or whether it is a parallel custom with the taking of the bones to a púnja-ngúrrim, I am unable to say.

Age of Pictures.

When asked, "Who made these pictures?" any Worróra man will reply that they were made by the Wónjuna themselves. Several men have assured me that no man can make these pictures. Usually it is said by a Worróra man that they are there from long, long ago. But all these statements are open to grave doubt when one compares the present condition of the pictures in different places. Some of the men said to me that occasionally a man would renew a picture, but that the original had been put there by the Wónjuna himself. Some said that some of the pictures may have been made by certain of the old men, whom they named. But none had made a painting of Wónjuna himself. At Piriállu, for instance, there is a large horizontal picture of Wónjuna facing the sea. This picture is nearly obliterated by the rains, and soon will cease to exist. This cave is no longer venerated because of its desecration.

Several caves have pictures that are now in a bad state of repair. One of these is about a mile and a half from Kunmúya Mission Station and has been visited by the children; another looked down on the boat landing, and the pictures there had become almost obliterated. Again, in some caves, the roof of the place showed where pictures had been, but, with the annual tropical rains, the clay of the paintings had become damp and flaked off the rock. The vertical pictures, where not renewed, seem to have kept better than those in a horizontal position on the overhanging face of the rock.

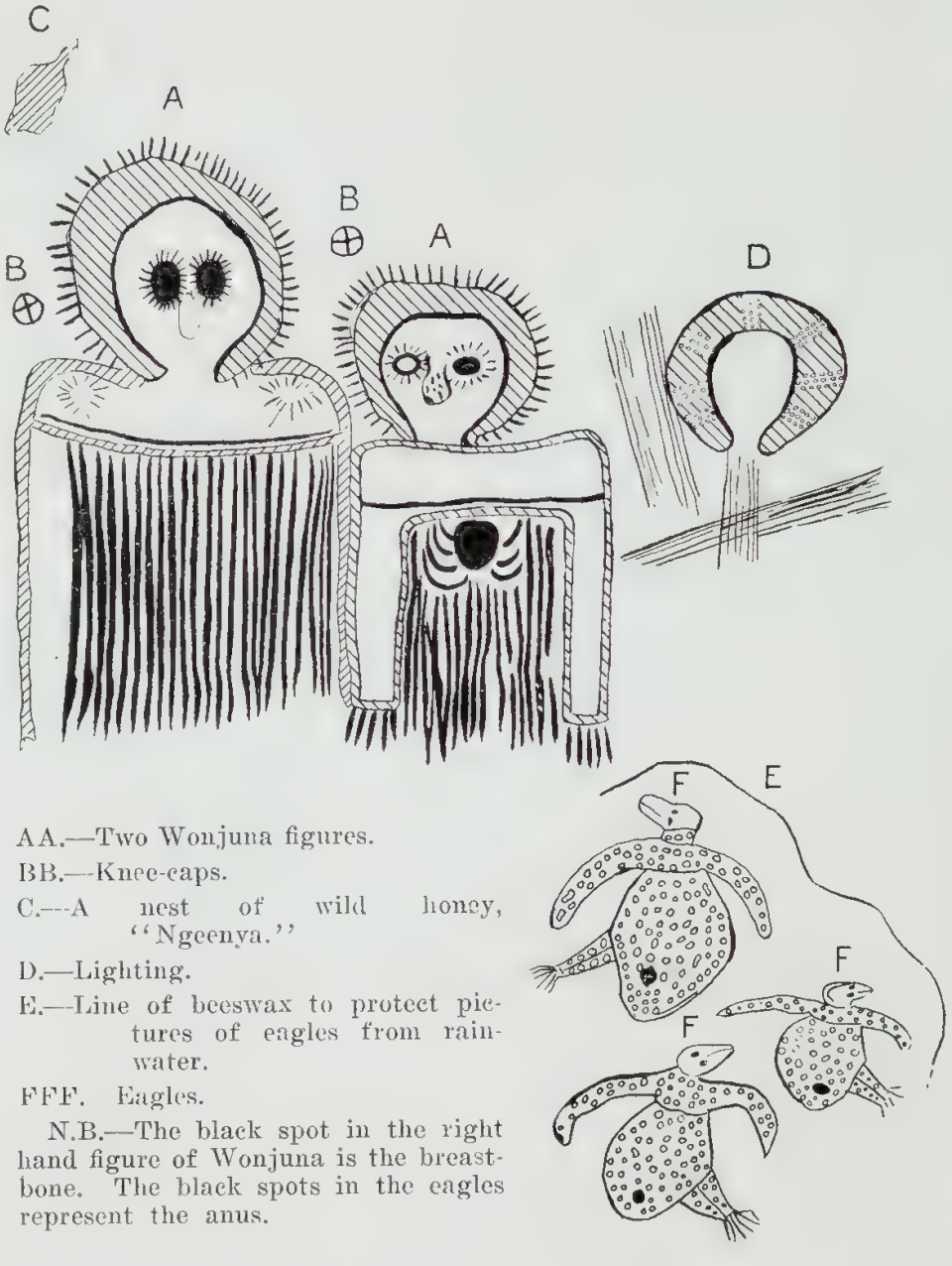
Nearly always when questioning men about a myth or picture, I am referred to Kánaway (Fig. 1). Kánaway is an old man who is the recognised Iná̀iiri (literally, "great man," *i.e.* head), of the Worróra. The Kunmúnya country, the locality in which is now the Kunmúnya Mission, is Kánaway's own demesne. Is it a question concerning a rock or hill in the Kunmúnya district? Kánaway knows all about it. Is it the meaning of a picture in this district? Kánaway knows all about it. Is it an old story of the mythical times? Kánaway knows all about these stories.

There are other bunmúndia (bunmúnja, singular form, is a "doctor"). There are other chórlbuddia (chórlbudda is an orator). There are other rain-makers. But Kánaway is Iná̀iiri (as head of the Mission, I, myself, am usually spoken of by the people as Iná̀iiri. In Mission concerns I am Iná̀iiri. In tribal questions Kánaway is Inaiiri).

For some years past, Kánaway, who is now an old man, has been a pensioner at the Kunmúnya Mission and usually lives at the Station, where he receives his food daily. But occasionally, Kánaway goes for a "walk-about," living in the bush for several weeks, then returning to the station to resume his position as pensioner.

During the last wet season, February-March, 1929, Kánaway went for a tour through his country. As one man told me, he had gone to look at his country. One week after his departure I found, on the rock overlooking the boat landing, at the place named Ngáw-gaw, three new paintings, of a kunjáwrinya (fresh-water tortoise), a bulgúja (dugong), and a liver of stingray, "ubúnu." These were on the rock face where previously were faint signs of pictures that had been obliterated by the rain. My two companions, young men, told me that Kánaway had made these new pictures. In public these two men might have denied any knowledge of how these pictures got there; but to me, privately, they were ready to admit what was obvious to us all, that they had been freshly executed, and we all would have said without hesitation that Kánaway was the painter. I have not yet sufficient idiomatic command of the Worróra language to intimately discuss these things with Kánaway himself, as he is an old man, secretive, and not easy to approach through my stumbling Worróra tongue. I hope, in time, to learn much that will be of interest from himself. Meantime I have been pleased to have established the fact that the rock paintings, while some of them may be of vast antiquity (in sheltered positions), are mainly subject to renewal, or fresh execution, periodically, by Worróra men now living. This execution is done secretly, and the general mass of the tribe are told that the pictures are the work of no man's hand. Though an old man, with failing powers, Kánaway, as head of his people, still feels the urge to go out and ensure the food supply of his people by placing in the picture caves representations of the objects that need their pictures for their increase.

PLATE II.



AA.—Two Wonjuna figures.

BB.—Knee-caps.

C.—A nest of wild honey, "Ngeenya."

D.—Lighting.

E.—Line of beeswax to protect pictures of eagles from rain-water.

FFF. Eagles.

N.B.—The black spot in the right hand figure of Wonjuna is the breast-bone. The black spots in the eagles represent the anus.

C. B. K'Ason, del.

Rockface at Nyimundum Rock, Kimberley Division, W.A.

Vide Figure 12.

In one picture cave, that named Nyimúndum, there is a very interesting instance of an attempt to preserve pictures from the rain (Plate II. and Fig. 12). There are three pictures of Waráhninya (the wedge-tailed eagle) in this cave, or rock. Over two of them is a semicircle of beeswax stuck on the rock. This place is a Woonggúru of one of my companions on a visit to it recently. He is named Nyimúndum, after the rock. I asked him who had put beeswax over the eagle pictures. He thought his father might have done it. But Nyimúndum's father has been dead for some years and the beeswax lines are not very old. Evidently, as Nyimúndum had not visited this rock for about ten years, before accompanying me, another man had put this protection on the rock. The painted rock face is not exposed to the weather, but it slopes in such a way that rain falling on the top of the rock might run down and damage the pictures of the eagles. This rock, Nyimúndum, supplies an instance of how the Worróra can hold two conflicting traditions without troubling to reconcile them. On the weathered under-surface of the rock are two pictures of Wónjuna. Both have the name Lóóngamunna. Lóóngamunna was a Wónjuna who came from the wind, walked about the country east of the Prince Regent River, then finally went to earth at this rock, where he left his picture, and where his ingáhnj (spirit) evermore abides, ready to give children to men who may sleep and dream there.

But beside the Wónjuna pictures are the three eagle pictures. The parallel tradition tells that Waráhninya (the wedge-tailed eagle) came from the south side of the Prince Regent River and flew to this place. Here Maráhninya made this rock for its yandúlpa (house) and laid a row of eggs on the top of the rock. But the eagle said, "This rock slopes too much. I had better go down into the shade." So the eagle went down below to the sheltered side of the rock, where the three pictures are still. The eggs remain on top of the rock in the form of a row of stones, placed evenly across the top. These remain there so that the eagle will not wish to go away. (The eagle's clutch of eggs is usually two, and there are about twenty stone "eggs," but this detail is consistent with usual lack of logical conclusion among the Worróra.)

Apart from the pictures in the rock cavities there are many stories told in connection with Wónjuna. Some of these tend to leave the impression that Wónjuna is regarded as the Supreme Creator; others again, as connected with localities where a Wónjuna has his individual name, leave the impression that Wónjuna is the name of many local creators. Probably there are elements of belief in a Supreme Creator, but these have not been thought out to a system of monotheism.

There is a supernatural being called Ngajáía, who dwells in the sky. He is not seen, nor is he often spoken of. I have not found any very clear conception of Who or What Ngajáía is. He may prove to be the Supreme Spirit, the First Cause, but I doubt whether the Worróra have got that far in their thinking. There is a supernatural being called Wallangúnda, who is represented in the sky by the two "pointer" stars of the Southern Cross. He walks about in the sky and hunts there. When I asked, "Who put him there?" I was at once told, "Wónjuna put him there."

In the local story of the Great Flood it was Wónjuna who made the flood.

The attitude of the present generation to Wónjuna is illustrated in the rain-maker's song, as follows:—

Kāllŭːŭ | Wōnjŭnă | nyīnmĕhrĭ | mēāh
Pāră-pă | rōā | mēāh
Pāră lĕ | līwā | nyīnmĕhrĭ | mēāh
Jījăi, | Jījăi,
Drrrrr . . . . . .

The rhythm is almost a complete Sapphic.

Kálluru is a Ngárrinyin Tribe word for Wónjuna:.

Nyínmehri = you are telling; Méah = indeed.

Pára = lying, false. The second line means, "Why do you lie to me?"

Pára Leĺwa. Pára = false, leĺwa = an end, *i.e.* the line means, "Cease from lying to me."

Jijai is the child's pet word for father (the normal word for actual father is Irai).

Drrr.... is the croak of a frog.

In this song the rain-maker calles on Wójuna not to deal falsely with him, but to hear him as father. The croak is sympathetic magic, inducing rain by giving the sound of the frog that croaks when rain falls.

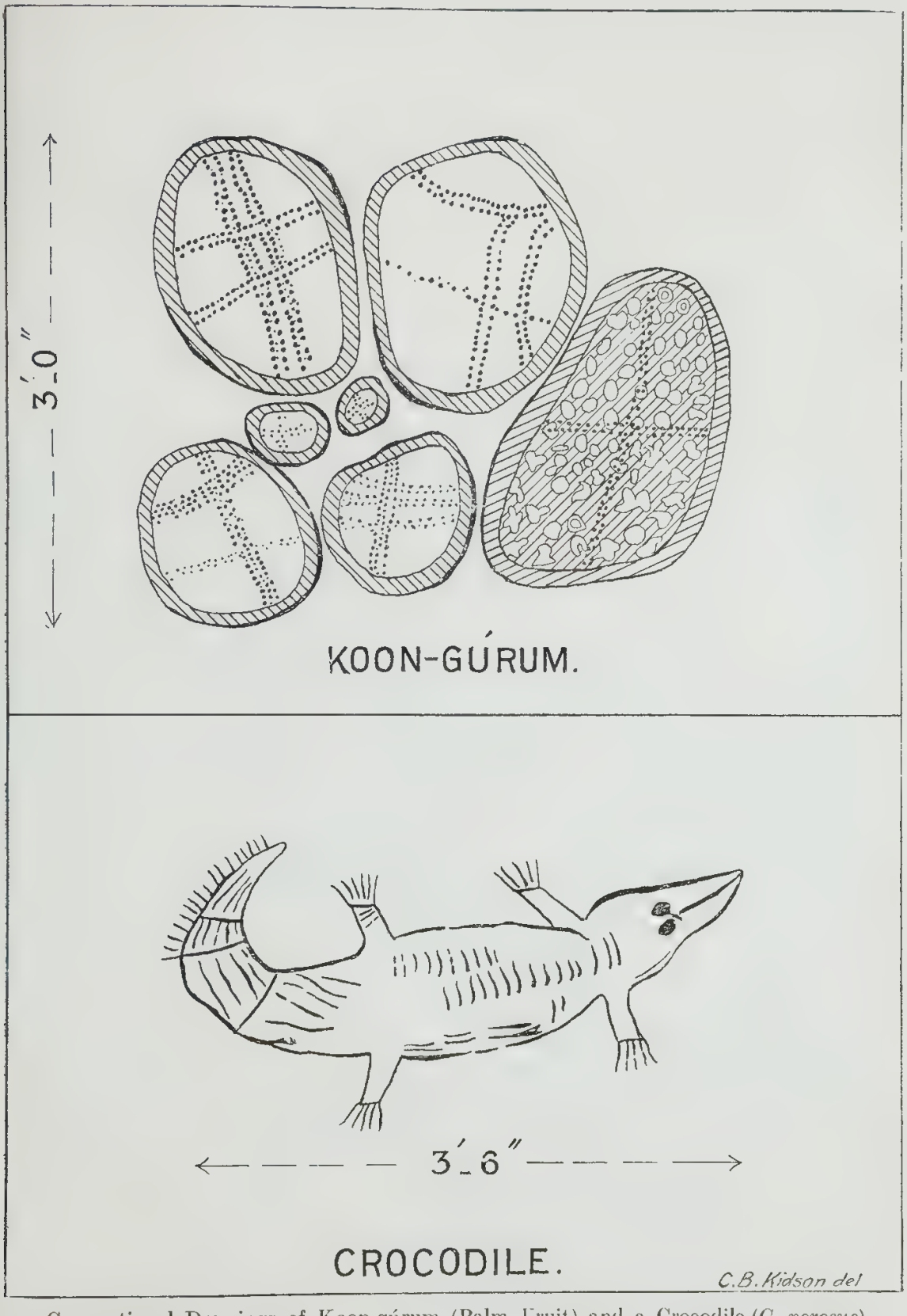
I append an illustration (Plate IV.) that appeared in the "London Times," Weekly Edition, 29th March, 1928, showing rock paintings in North Africa, of great antiquity. Several points of resemblance to the rock paintings of North-West Australia will be at once seen, *e.g.*, the halo-like drawing of the hair, the absence of mouth, the presence of circles, whole or divided, beside the figures.

Regarding the universal absence of mouth in the Australian pictures: When I first saw one of these pictures I said to my two companions, an old and a middle-aged man, "He has no mouth." They gravely looked at one another and, after a while, one solemnly said, "Iámunt káhri" ("He (has) no mouth"), which the other brilliantly supplemented by saying "Iwiuk káhri" ("He (has) no teeth").

Lately I have tried questioning several men as to whether there is any reason known to them for the absence of a mouth. Most have just looked vague and had nothing to say. One of the most intelligent said, "I do not know why Wónjuna did not leave any mouth." An old man, who was describing to me a bird, drew what he imagined to be a picture of it on the ground. He gave it a human face, but gave the face no mouth. A young man who drew on the bark wall of his hut a picture of a woman, gave his drawing a mouth. This young man had a good deal of experience among white people. The little children now at the Mission School will draw the usual children's sketches of people.

I am of the opinion that the drawing of a human face without mouth, among the older generation, is the conventional way of depicting a human face. Whatever the original reason for not putting in the mouth, among the Worróra it has come to be the usual way of drawing a face, and it does not occur to the normal Worróra man that there is anything lacking in his drawing.

PLATE III.



Conventional Drawings of Koon-gúrum (Palm Fruit) and a Crocodile (*C. porosus*).

Clothed Figures.

Are the human figures clothed?

Reproductions of such rock paintings as are here described have frequently seemed to indicate that the human figures represented are clothed.

The Worróra people wear no clothes in their original condition. There is a word "wábi" which means any ornament worn on the body, and this word is now used by the Worróra to mean clothes, such as they are now acquainted with, of European style.

I have not seen any pictures so definitely "clothed" as appear in some reproductions by white travellers, though certainly some of the Wónjuna do seem to be clothed.

The evidence of the Worróra men themselves is conflicting. Four men, who recently accompanied me on a long trip in the bush when we visited several picture caves, said definitely that the marks on the figures were not clothes, but were "Pullémba-ngúrra," *i.e.* ornamentation.

On the other hand, an elderly man told me he would show me a very fine Wónjuna, and he said, "He has wábi," meaning, in this case, that the Wónjuna did have clothes. Before the advent of white people this man could not have had any idea of clothes, yet he seemed to recognise in the picture of Wónjuna which he was describing to me, clothing as worn by civilised races.

It is usual, in painting beasts, to separate the limbs from the body, giving the appearance of neck-band, sleeves, etc. (*Cf.* Pictures of eagles at Nyimúndum and of crocodiles at Koon-gúrum place. F. Plate II., Plate III., and Fig. 6.) Judging from the pictures that I have seen, and comparing their ornamentation with similar ornamentation that the men now paint on each other's backs and chests, during certain ceremonies, I should have said without hesitation that the pictures were not intended to represent clothed beings. Only the remarkable saying of that elderly man makes me think that, perhaps, after all, a tradition of clothed beings has persisted in the pictures, though the Worróra people had no conception of clothes for untold ages.

Symbols.

It has been attempted to show, from illustrations of some of the rock drawings in North-West Australia, that characters appearing in these drawings are writing.

Whatever may have been the original significance of some of these marks, they are now, to the present generation of Worróra, either portraits, representing fruits or berries, used as food, or conventional symbols for objects such as parts of the body.

At Nyimúndum, immediately above the right shoulder of the left-hand figure of Wónjuna, appears a cross within a circle (Plate II. and Fig. 12). The circle is about three inches in diameter. There are two other similar marks on this rock. My companions informed me that this crossed circle represents the knee-cap, and that this particular one, above the Wónjuna's shoulder, was put there by Nyúnggawona's Kúkai. Nyúnggawona is an old man now living. Kúkai

is the term of relationship for mother's brother. This Kúkai of Nyúnggawona has long been dead. The Worróra have a system of gestures denoting relationship. The gesture of Kúkai is not to touch the knee, but to put the hand on the shoulder-blade. To touch the knee is the gesture of "Rumbúrrb," or "Rumbúdba," the relationship between two persons, in which it is forbidden for either to marry, speak to, or look at each other.

I was not able to establish any connection between the crossed circle that represents the knee-cap and a relationship gesture. All that my companions could say was that Nyunggawona's kukai put it there to show kúkai.

A noteworthy symbol that frequently occurs in connection with the Wónjuna pictures is the symbol for lightning. This is either a drawing of several parallel straight lines, or, more elaborately, several straight lines emanating from a more or less circular figure that looks like a representation of the sun.

There are two Worróra words for lightning: Múlngirinya and Múrrungúnnunya. The word for sun is Múrrungunya. The word Múrrungúnnunya looks like a cognate word, and the idea of lightning would seem to be cognate with the idea of sun, from a remark of Nyimúndum, who explained to me what the circular lightning symbol was. He said it was "Múrrungúnnunya (which word I knew to mean lightning), "which we see when it rains; like the sun," and waved his arm to represent a flash of lightning passing across the sky.

There is one other type of rock painting that must be noted: the stencilling of hands and feet. These occur, but not frequently, in the Wónjuna caves. The Nyimúndum rock has Wónjuna pictures, eagles, kangaroo, crocodile, fish, "sugar-bag" (wild honey), on one face of the rock, and on the other face several stencilled hands and feet. A cave at Minggóonya is filled with hands and feet, and no other pictures.

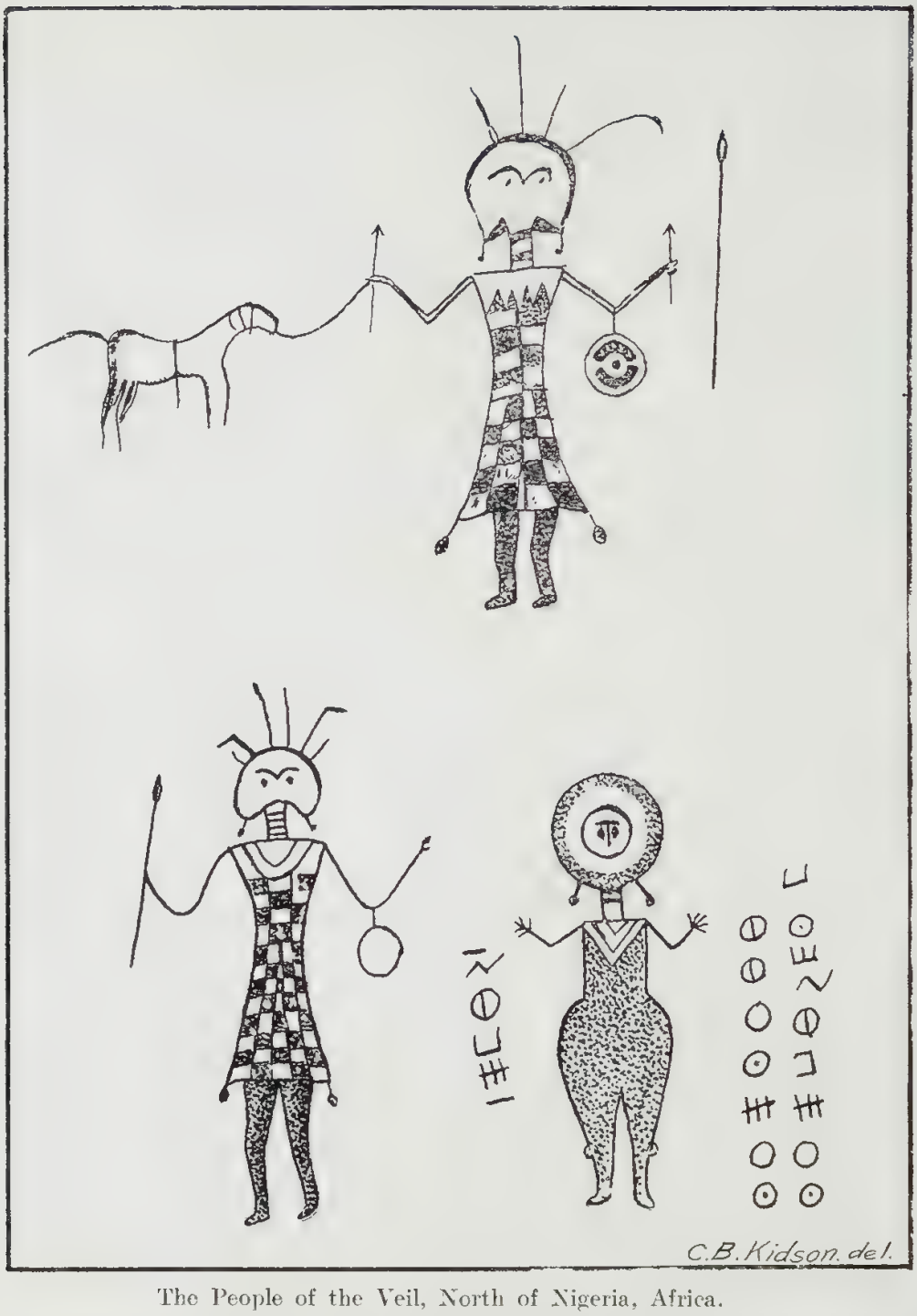
Minggóonya was the original site of the Mission Station, now established at Kunmúnya. When the Mission was first established it soon became a rendezvous for the Worróra, then, gradually, a neutral meeting place for Worróra, Ngárrinyin, and Wúnambullu tribes. The men soon fixed on a cave behind the site of the original Mission Station in which to put their hand and foot prints. One day I found a newcomer, lying on his back, with his foot on the rock face, squirting a mixture of white clay and water from his mouth over his foot. Noting how this cave soon became filled with stencilled hands and feet, and remembering that the aboriginals can distinguish each other's footprints with the same readiness that we distinguish each other's handwriting, I am of opinion that the stencilling of hands and feet has no significance beyond expressing the same urge that makes the schoolboy leave his initials on desk and wall.

Addenda.

(1) "The Human Figure.". . . *Wónjuna.*

Since this paper was written I have learned that each local Wónjuna has a representative now living. In every case that I have investigated, this living representative claims the Wónjuna as his "kúkai," *i.e.* his mother's brother. There are now living, among the Worróra, persons who

PLATE IV.



The People of the Veil, North of Nigeria, Africa.

Two of the rock-drawings found on the mountainous plateau of Air which lies due north of Nigeria. Considerable enlightenment as to the origin of the mysterious Tuareg, the "veiled people" of the Sahara, is expected to result from this discovery. These drawings are similar to those drawn of the North African people west of the Nile by the Egyptians in the XIX. Dynasty.

bear the names of some of the Wónjuna. These name-sakes are not the men who claim the Wónjuna as their kúkai. The man who claims the Wónjuna of a district as his kúkai is further regarded as being the head of that locality, a kind of "chief of the land." Kánaway claims the Wónjuna Punúllgurra, of Piriállu, as his kúkai. This puts him in line with the other men in his being regarded as the head of the territory near Piriállu, *i.e.* the Kunmúnya territory; but, in addition to being the living representative of the Wónjuna, and so a head of a locality, Kánaway is head of all the Worróra. Other men who claim a Wónjuna as kúkai are heads of their own localities. Kánaway is this and head of all the others.

(2) Age of Pictures. I have since secured a photograph of a painting of a Wónjuna that was executed, or re-painted, during the wet season of 1929, between January and March. This picture (Fig. 13) shows an unusual drawing of the hair. I am told that the club-shaped marks surrounding the network of hair are "marúku," *i.e.*, flowers, for ornament. None of the four men, who were with me when I secured this photograph, knew what kind of flower was intended. The mark on the breast is the breast-bone. The divisions do not represent clothing, but separate the limbs.

(3) Bone Caves. I have since learned of more, notably one near Hall Point (Worróra), and one on one of the Montgomery Islands, the latter being the sacred cave of the Yáujibaia Tribe.

EXPLANATION OF PLATES AND FIGURES.

Plate I.—

Locality Map showing the rock paintings in a portion of the Kimberley Division, Western Australia.

Approximate boundary of Worrora Territory.

The names are taken from the official map.

Those shown ⊙ are the localities of picture caves, and those shown △ are of picture caves which are also bone caves.

Plate II.—Rock face at Nyimundum rock.

AA.—Two Wonjuna figures.

BB.—Knee-caps.

C.—A nest of wild honey, "Ngeenya."

D.—Lightning.

E.—Line of beeswax to protect pictures of eagles from rain-water.

FFF.—Eagles.

N.B.—The black spot in the right hand figure of Wonjuna is the breast-bone. The black spots in the eagles represent the anus.

Plate III.

Conventional drawings of Koon-gurum, fruit of a palm and a crocodile (*C. porosus*).

The outlines are the shell of the fruit, the dotted lines are ornament.

Plate IV.—The People of the Veil—

Two of the rock-drawings found on the mountainous plateau of Air (which lies due North of Nigeria). Considerable enlightenment as to the origin of the mysterious Tuareg, the "veiled people" of the Sahara, is expected to result from this discovery. These drawings are similar to those drawn of the North African people West of the Nile by the Egyptians in the XIX. Dynasty.

Figures—1. Kanaway, head of the Worrora Tribe.

2. Piriallu, a picture place. The position of the cave is indicated by arrow. *Vide* Plate I.

3. A fish at Piriallu. Note human-like face ; no mouth.

4. Koon-gurum, the fruit of a palm. Cf. Plate III.

5. The Koon-gurum Tree ; fruit is seen near the gun barrel.

6. Crocodiles at Koon-gurum Cave.

7. Paleed-paleera Gorge. The picture cave is in the rough rocks at right.

8. Wonjuna at Paleed-paleera. The black spot on breast is the breast-bone. This figure is painted over a partly obliterated much larger figure of Wonjuna. The club-like object at lower left is a "Korja," an edible yam.

9. Two figures at Paleed-paleera :
Upper right, "Kooninjin," i.e. native porcupine (Echidna).
Lower left, liver of stingray "Ubunu."

10. Two figures from Puroolba Cave :
Three drawings of "flying opposum," "Lunggumunya" ; one figure (dark tadpole-shaped object) is "Ngeenya," a comb of wild honey. Animals in red, honeycomb in yellow.

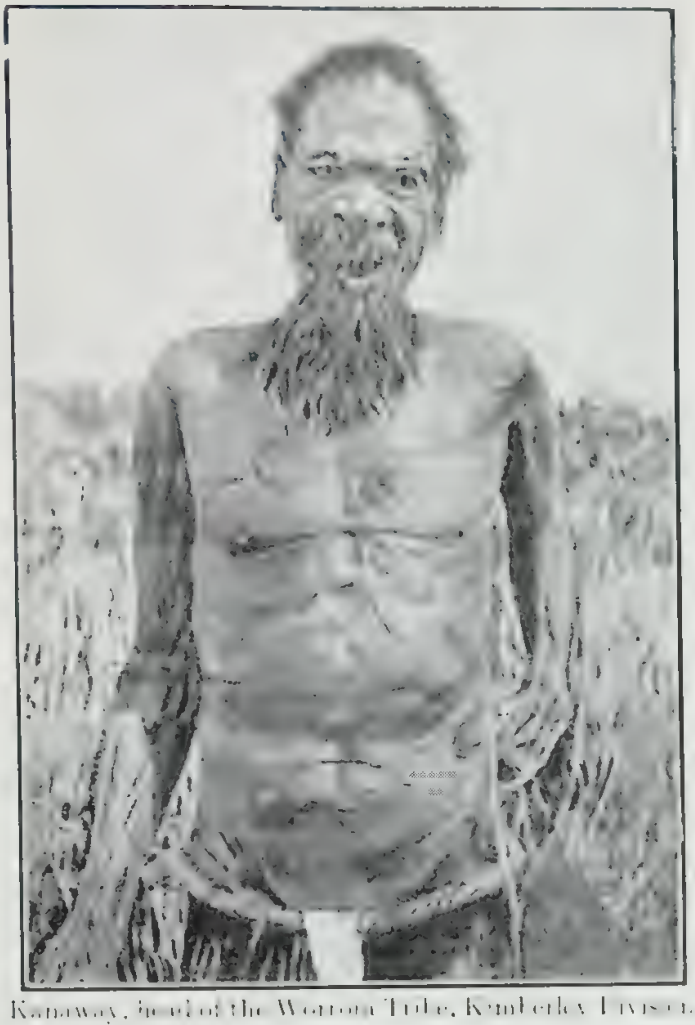
11. Nyimundum Rock, showing row of stones representing the eggs of the eagle on top, also heap of stones at right foreground, by which men climb to top at ceremonies.

12. Figures at Nyimundum. Cf. Plate II.

13. Picture of Wonjuna at Kundiri 'ngurrim, near Hall Pt.—The hair is shown as a net-work. The club-shaped marks surrounding the hair are "flowers" for ornament (not known what kind of flowers). The mark on breast is the breast-bone. The divisions are not clothing, but separate the limbs. This picture was *painted, or re-painted by two men in the wet season of* 1929, at some time between January and March.

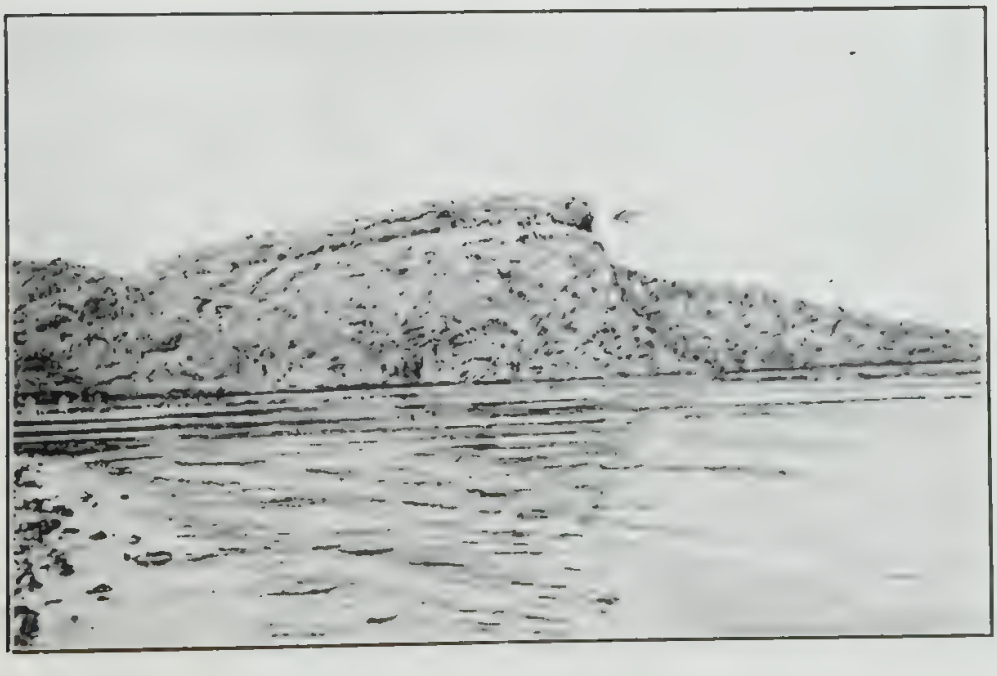
14. Men's bones in Ngalan-nguru Cave, on one of the Montgomery Islands.—
Upper left, a fairly recent parcel of bones, intact.
Upper right, bones fallen out of an ancient, decayed parcel.
Lower, a decaying parcel of bones, with bones falling away from the parcel.

Fig. 1.



Kanaway, head of the Worrora Tribe, Kimberley Division.

Fig 2.

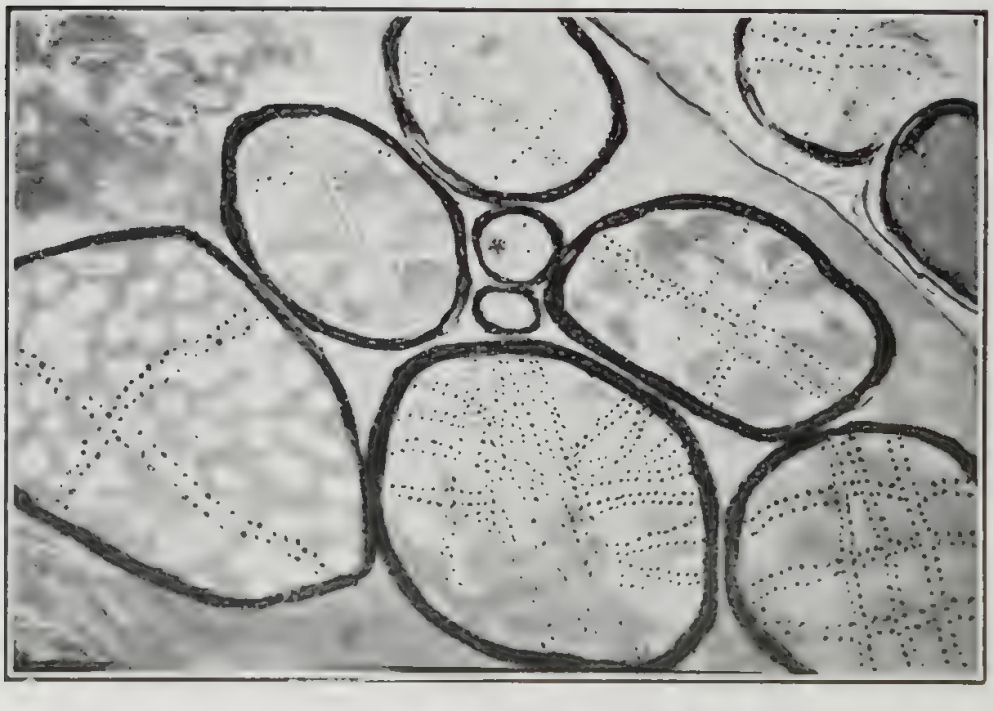


Piriallu a picture place, near Port George IV., Kimberley Division.

Fig 3.

A Fish at Piriallu, near Port George, Kimberley Division.

Fig. 4.



Koongurum—The fruit of a palm, *c.f.* Pl. III.

Fig 5.

The Koongurum Tree.

Fig. 6.

Crocodiles at Koongurum Cave, Kimberley Division.

Fig. 7.

Paleed-Paleera Gorge, Kimberley Division.

Fig. 8.

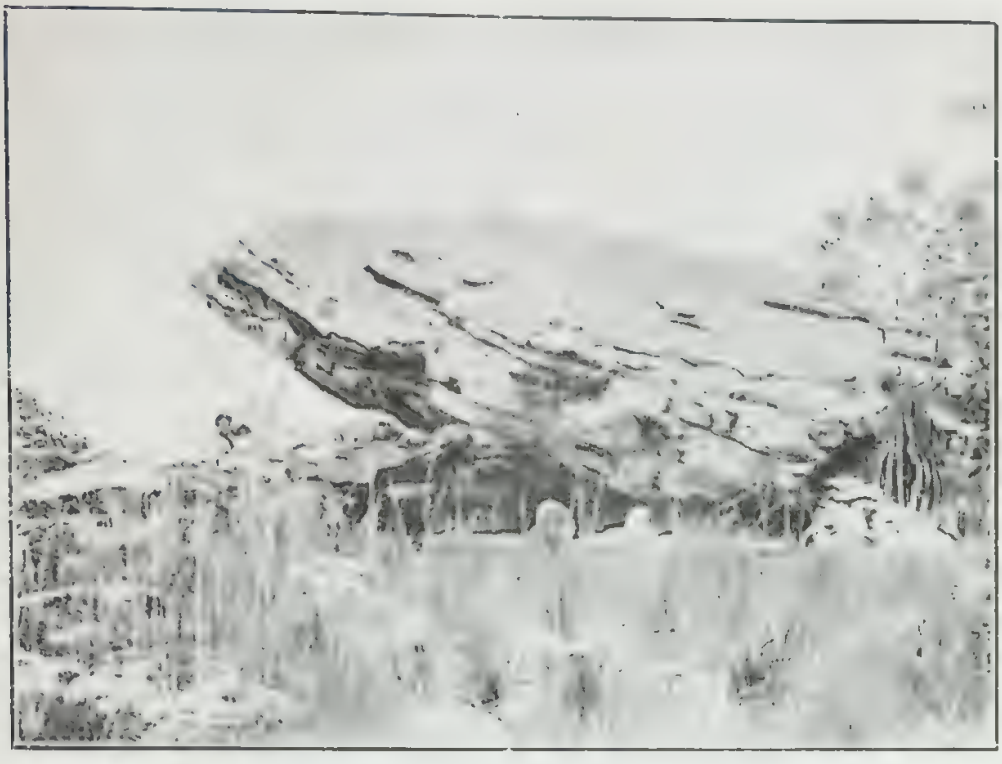
Wonjuna at Paleed-Paleera, Kimberley Division.

Fig. 9.

Two Figures at Paleed-Paleera, Kimberley Division.

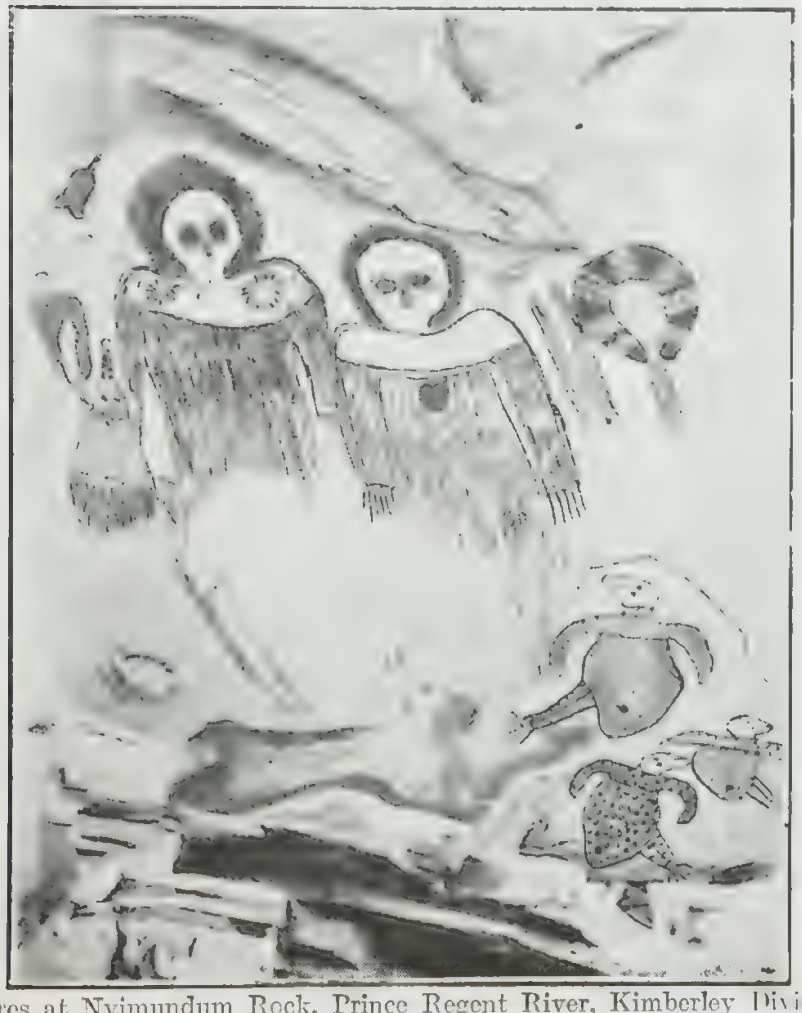
Fig. 10.

Two Figures from Puroolba Cave, Prince Regent River, Kimberley Division.

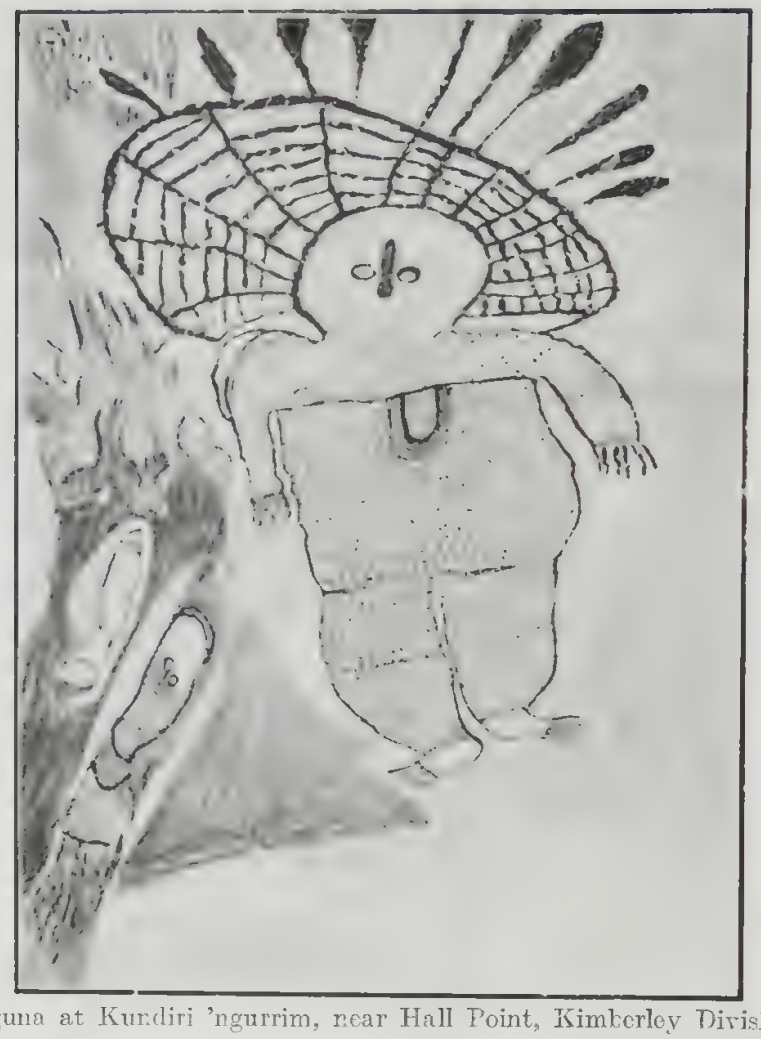


Nyimundum Rock, Prince Regent River, Kimberley Division.

Fig. 12.



Figures at Nyimundum Rock, Prince Regent River, Kimberley Division.
c.f. Plate II.



Wonguna at Kundiri 'ngurrim, near Hall Point, Kimberley Division.

Fig 14.

Three parcels of men's bones in Ngalan-nguru, Montgomery Islands, Collier Bay, Kimberley Division.

2.—CONTRIBUTIONS TO THE MINERALOGY OF WESTERN AUSTRALIA.

SERIES V.

(With one Figure.)

By

EDWARD S. SIMPSON, D.Sc., B.E., F.A.C.I.

Read, 8th April, 1930; *Published*, 24th July, 1930.

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(1) ANHYDRITE, KALGOORLIE, CEN. DIV.

We owe this, the first discovery of anhydrite in Australia, to the keenness of Mr. W. R. Feldtmann as a field mineralogist. During 1929 he noticed in some small quartz veins at the 1,100ft. (335 metres) level of the Perseverance G.M., masses of a translucent mauve-coloured mineral not unlike fluorite. Laboratory examination, however, showed it to be anhydrite, "violet" coloured types of which are said to be rare.* The rock in which the vein occurs is a carbonated and chloritised greenstone of Archæan age.

The mineral is in coarsely crystalline masses, single cleavages being traceable for distances of 1 to 3 cm. The characteristic three rectangular cleavages are strongly marked. Individual cleavage blocks are translucent in thicknesses of 3 to 10 mm., whilst thin flakes are perfectly transparent. Multiple twinning is noted in many of the pieces of the coarse powder when viewed under the microscope, there being often as many as five successive plates in a width of 0·1 mm. The traces of these plates make angles of approximately 45° with the cleavages, indicating that the twinning is on the already recorded plane (101), the calculated angles for which are 48° 13′. and 41° 47′. This twinning can be detected by the naked eye as a series of fine striations on some of the cleavage blocks.

The colour of the mineral is mostly pale mauve (63′ f) to a little darker than light mauve (63′d), but in some specimens the colour diminishes in parts to practically colourless. The powder under the microscope is perfectly transparent and colourless. It is usually bounded by the perfect rectangular cleavages, and gives a straight extinction in all directions, with very high birefringence.

*Winchell: Elem. Opt. Min. II., 100.

A mauve-coloured cleavage fragment was selected for analysis with the following results :—

	%	mols.
CaO	40·47	722
SrO	·71	7
BaO	·05	0·3
SO_3	58·94	736
H_2O	·40	22
	100·57	
G	2·97	

The small amount of water indicates incipient alteration to gypsum along the cleavages.

It was found that when ground to an impalpable powder the mineral dissolved rather readily in warm 5N. HCl or HNO_3, but that slightly coarser powder, such as would pass a 90-mesh sieve (max. diam. 0·18 mm.), took many hours to dissolve in nearly boiling acids of the same strength.

(2.) CELESTITE, KALGOORLIE, CEN. DIV.

In the same level of the Perseverance Mine which yielded specimens of strontium-bearing anhydrite, Mr. Feldtmann observed granular masses of a pink colour in a small quartz vein. These on examination, have proved to be an intimate mixture of calcite (about 30 per cent.), quartz (about 10 per cent.), and celestite (about 60 per cent.).

The celestite was separated from its associates by first treating with cold, very dilute, hydrochloric acid, and, after drying the residue, floating off the quartz with methylene iodide. The residue under the microscope was transparent, with a mean refractive index of 1·630, and a moderately low birefringence. By floating in silver thallium nitrate its specific gravity was proved to be 4·08. Chemically it was found to be slowly attacked by hot strong HCl, the solution on diluting giving a precipitate with barium chloride. By fusing with $KNaCO_3$ a carbonate was obtained easily soluble in HCl, the solution giving strong reactions for strontium (confirmed by spectroscope) and weak for barium. Lead was absent.

The optical and chemical properties leave no doubt that the mineral is celestite (strontium sulphate), a mineral not previously known in the State.

(3.) AXINITE, TALBOT BAY, KIM. DIV.

In 1929 when E. C. Francis was exploring the west coast of the Kimberley Division, he found a brownish mineral to be abundant at a point on the shore of Talbot Bay, a deep inlet about 12 miles S.E. of Yampi Sound. This mineral has been found to be axinite, one only previously known in the State in a few small specimens collected by J. A. Thomson at Kalgoorlie.

The mineral occurs in a narrow, much veined, band of rock, characterised by seams of quartz, calcite, and epidote, with occasional schorl, and said to be found in greenstone schist at its junction with gneiss. It exists in wedge-shaped crystals and crystalline masses embedded in vein quartz or calcite, or penetrating both ways from a junction of the two. Single crystals have

been observed up to 2 cm. in length, and coarsely crystalline masses up to 250 grammes in weight. It is almost impossible to remove the crystals from their matrix without fracturing them greatly. One crystal which was extracted whole was a combination of *M* (1–10), *m* (110), *b* (010), (2–30)?, *r* (1–11), *s* (201), and *y* (021).

The crystals vary greatly in translucency, some being opaque in thicknesses over 0·5 mm., others being translucent up to 4 mm. The colour too, is variable, ranging from Ridgway 69^4, dark vinaceous grey, to 1^4, purple drab, and nearly to 1^3i, deep livid brown. The fine powder under the microscope is transparent and practically colourless, with medium birefringence.

Before the blowpipe the mineral fuses easily with intumescence, and with CaF_2 and $K_2S_2O_7$ in a relatively cool flame gives the green colour characteristic of boron compounds.

An analysis was made of some of the more transparent brown mineral, carefully separated with methylene iodide. For comparison are given recent analyses of the mineral from Prali (Italy), and Bourg d'Oisans (France):

	Prali.	B. d'Oisans.	Talbot Bay.		
	%	%	%	mols.	
SiO_2	41·26	42·78	42·14	702	
Al_2O_3	18·74	17·67	17·67	173	184
Fe_2O_3	2·02	·99	1·74	11	
FeO	6·11	6·02	6·81	95	
MnO	4·43	2·99	3·09	44	191
MgO	1·75	2·41	2·06	52	
CaO	19·52	20·16	19·96	356	
B_2O_3	4·70	6·12	5·56	80	
H_2O	1·71	1·40	1·56	86	
Total	100·24	100·54	100·59		
G	3·31	3·29	3·25		

Dividing the molecules throughout by 88 we obtain the formula

$$H_2O \cdot 2FeO \cdot 4CaO \cdot 2Al_2O_3 \cdot B_2O_3 \cdot 8SiO_2$$

which is the same as $HFeCa_2Al_2B(SiO_4)_4$.

This is the formula for axinite accepted by N. H. and A. N. Winchell.

(4.) CHLORITOID, KALGOORLIE, CEN. DIV.

In 1915 the writer showed by a detailed comparison of chemical and physical properties that the many minerals described as belonging to the Chloritoid Subgroup could be reduced to one species, chloritoid, and two varieties, viz., ottrelite (manganiferous chloritoid), and sismondine (magnesian chloritoid).* The general formula for the species is $H_2(Fe, Mn, Mg)Al_2SiO_7$. The apparent excess of silica noted in some analyses of ottrelite, etc., is simply due to minute inclusions of quartz, as can be proved by microscopic examination of the minerals and decomposition of the analytical material by concentrated sulphuric acid, followed by Lunge's alkali solution. Phyllite, masonite, newportite, struverite (Brezina 1876), venasquite and salmite are unnecessary synonyms for normal chloritoid or one of its varieties.

*Geol. Surv. W. Aust. Bull. 64, pp. 64–78. N. H. and A. N. Winchell, Elem. Opt. Mineralogy II., p. 385.

In 1912 the writer described a rock on the Lake View Townsite, Kalgoorlie, which carried many well defined discs of a mineral referred to as ottrelite.* The mineral itself had not been separated and analysed, but, the analysis of the rock as a whole showing a relatively high proportion of manganese, it was assumed that the chloritoid was also rich in manganese. The mineral has now been separated and analysed, with the result that it proves to be a normal chloritoid with occluded quartz granules.

The rock mass in which chloritoid occurs at the Lake View Townsite appears to occupy quite a small area of the Archæan greenstone complex. What it lacks in size, however, it makes up in variations of type. In the writer's collection are no less than a dozen rock specimens from this area, each showing some individual form of structure or mineral composition, but resembling one another in being freely sprinkled with small discs of chloritoid, usually about one millimetre in diameter, and one quarter that in thickness. Some of these rocks are quite massive, others coarsely brecciated, others slightly or highly foliated. All are variants of the intrusive quartz dolerite, as shown by typical relict structures to be seen in thin slices, such as large skeletal ilmenites, or optically parallel archipelagoes of primary quartz. They range from a massive green chlorite rock with less than 10% of carbonates (See Analysis J), through chlorite schist and grey calc schist with 20% of carbonates (See Analysis A), to a pale yellow pyritous mica schist with a smaller proportion of carbonates.

The proportion of chloritoid in the rock varies from about 5 to 15 per cent. of the whole. In some of the rocks it is evenly scattered throughout the whole, but in the brecciated ones it is often more plentiful in the fillings between the broken fragments, and in the schists is often much more plentiful in some bands than in others.

The composition of two of these rocks was as follows :

	Chloritoid Rocks Kalgoorlie.	
Specimen.	J.	A.
SiO_2	44·93	50·94
Al_2O_3	14·66	12·04
Fe_2O_3	2·68	2·74
FeO	20·12	9·44
MnO	·38	1·06
MgO	4·63	3·04
CaO	2·17	5·47
Na_2O	·02	1·28
K_2O	·16	·66
H_2O |	6·16	2·81
H_2O	·11	·16
TiO_2	·90	1·09
CO_2	3·34	8·24
P_2O_5	·09	·45
FeS_2	*nil*	·77
Cr_2O_3	?	*nil*
V_2O_3	?	·09
ZrO_2	?	trace
BaO	?	·02
Total	100·35	100·30
G	2·95	2·88

* Geol. Surv. W. Aust. Bull. 42, pp. 142–3.

Approximate mineral composition :—

Chlorite	48·4	14·2
Quartz	31·8	32·9
Chloritoid	8·6	14·7
Ankerite	7·8	18·6
Ilmenite	1·7	...
Rutile	...	1·1
Muscovite	1·3	5·6
Albite	·2	11·0
Apatite	·2	1·1
Pyrite	...	·8
Magnetite	trace	trace
Tourmaline	...	trace
	100·0	100·0

"J."—A massive, greyish-green chlorite rock.

"A."—A thinly foliated, fine grained, yellowish-grey to greenish-grey rock.

Specimen "E," a completely unweathered, light grey, calc-schist with much visible chloritoid, was crushed and concentrated with methylene iodide, and freed from traces of pyrite by levigation in water. The final product was examined under the microscope and found to be chloritoid free from adherent matter, but embracing some minute inclusions of quartz and rutile. By repeated fuming with sulphuric acid and treatment of the residue with Lunge's solution, it was possible to determine the silica present as free quartz separately. The analytical results obtained were :

	Kalgoorlie.			Yampi.	
	Concentrate	Recalculated.			
	per cent.	per cent.	mols.	per cent.	mols.
TiO_2 (Rutile)	1·46	...		...	
SiO_2 (Quartz)	7·35	...		...	
SiO_2 (Combined)	21·68	23·74	395	24·31	403
Al_2O_3	35·62	39·01	401	39·18	405
Fe_2O_3	2·78	3·04		3·56	
FeO	21·89	23·98	399	22·64	403
MnO	·45	·49		1·51	
MgO	1·47	1·61		2·76	
CaO	·93	1·02		trace	
H_2O	7·05	7·72	428	6·65	369
	100·68	100·61		100·55	
G	3·46	3·54		3·55	

The composition of the Yampi (Kimberley Division) chloritoid, analysed some years ago is tabulated for comparison. The figures show that when allowance is made for embedded quartz and rutile, detected microscopically and separated chemically, the ratio $SiO_2 : MO : M_2O_3 : H_2O$ proves to be the normal one for chloritoid, viz., 1 : 1 : 1 : 1.

Microscopic examination of slides of eight different types of chloritoid rock from the Lake View Townsite yields the following data. The mineral is usually rather evenly distributed in single crystals through the rock, but in some cases is more thickly grouped in bunches or narrow lenses. Rarely several crystals are connected together in a fan-like arrangement. Individual crystals are disc-like, about 0·5 to 1·5 mm. in diameter and one-quarter to one-third their diameter in thickness. When cut vertically they are seen to be sharply bounded by basal planes but to have ragged boundaries in the

prism zone. The latter feature is very evident also in basal sections, only rare traces of a hexagonal outline being noted. Every crystal shows multiple twinning on the basal plane, the individual layers usually extending only part way across the crystal. A similar feature was noted in the Yampi chloritoid and figured on page 75 of Geological Survey Bulletin 64.* Indications of basal and prismatic cleavages are observable. Most crystals are crowded with minute granular inclusions, of which quartz and rutile form by far the greater proportion. By shading off most of the transmitted light it is seen, in practically every instance, that the inclusions are far more plentiful towards the centre basal plane of each crystal, the boundary of the denser mass being concave towards top and bottom of the crystal.†

The Kalgoorlie mineral is strongly pleochroic, that in some rocks being more strongly coloured than in others. Typical schemes observed were :—

	(1.)	(2.)
X.	Chromium green	Rainette green
Y.	Cadet blue	Orient blue
Z.	Light dull green-yellow	Light chalcedony yellow

The dispersion is too strong to observe an extinction angle in white light. Even in sodium light readings were unsatisfactory owing to the abundance of inclusions and polysynthetic twinning. Most readings of the angle Xc were about 4 to 6 deg., but readings up to 11 deg. were obtained.

(5.) GAHNITE, GILLINGARRA, S.W. DIV., AND WODGINA, N.W. DIV.

Gillingarra.—On the slope of a hill about one mile N. of the Government Well at Gillingarra, a number of detrital specimens of gahnite have been found. The rock exposed in the immediate vicinity is an almost vertical mica schist, traversed by occasional epidiorite dykes and many small quartz veins. A few hundred yards to the East the junction of the schists with a gneissic granite can be observed. Both rocks are thought to be of Precambrian age.

The gahnite has been found as scattered grains, from less than one to several millimetres in diameter, freely distributed through loose boulders of reddish weathered mica schist, one specimen yielding 30 per cent. of its weight of the spinel when crushed and concentrated. This concentrate was used for analysis. A section of the rock shows it to be a muscovite schist with subordinate chlorite (often heavily ironstained), biotite, and quartz, and innumerable spheroidal and ovoid grains of transparent green isotropic gahnite. These grains vary in size from 0·1 to 5·0 mm. in diameter and average 1 to 2 mm. Most of them are devoid of crystal faces, but occasionally perfect octahedra have been observed on the fractured faces of the rock, and in the concentrates from it.

Other detrital specimens consist largely of a mixture of gahnite, vein quartz, and ferruginous laterite. A few loose detrital pebbles of practically pure gahnite have been seen. These are mostly only 1 or 2 cm. in diameter, but one weighs 250 grammes and has a density of 4·06, indicating a content of about 80 per cent. of gahnite. Such masses are invariably composed of a number of crystal individuals.

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*Compare also Rosenbusch-Iddings Micro. Physiog. of Rock-making Minerals, Plate XXI. Fig. 2.

† Idem Plate XXI., Fig. 3.

No specimen has yet been found in situ in either schist or quartz, nor are any other zinc minerals known in the vicinity. In Maryland, U.S.A., gahnite occurs in copper-bearing veins in mica schist, in Sweden in similar veins in gneiss, whilst in Finland, Madagascar and in other parts of the United States, it is found in pegmatite veins.

The colour of the Gillingarra mineral in mass is dark grey-green, that of the coarse powder (30 mesh) between 41^3 and 41^3i (Ridgway). It is translucent in thicknesses up to 0·5 mm.

The specific gravity of the cleanest concentrate obtainable with methylene iodide was 4·34. As this was found to carry 1·28 per cent. of adherent and included quartz, the true specific gravity is 4·38.

The refractive index was determined for me by Mr. H. Bowley by immersion of some of the analysed powder in varying mixtures of piperine with iodides of arsenic and antimony, using a sodium light. All the granules had a greater N than a mixture with 30% of iodides (N, 1·773), and a lesser N than a mixture with 35% of iodides (N, 1·792). Immersed in a mixture with 32·5% of iodides (N, 1·782) some grains were found to have a slightly higher N than the medium, some a slightly lower. The values of N for the piperine-iodide mixtures quoted above are those of H. E. Merwin, quoted by E. S. Larsen.* The figure obtained is somewhat lower than previously recorded values of N for gahnite, viz., 1·788, 1·790, 1·792, 1·815, 1·820. It is to be expected that the value of N will vary with different ratios of Zn to Fe and Mg.

For the analysis a concentrate from the mica schist was carefully separated with CH_2I_2, and covered for a few seconds with hydrofluoric acid, then washed and dried. Even after this treatment traces of quartz and muscovite remained, partly adherent to, and partly enclosed in, the gahnite granules.

The results obtained were :

	A.		B.	
	per cent.	mols.	per cent.	mols.
Al_2O_3	56·96	559	57·70	566
Cr_2O_3	·09		·09	
ZnO	30·98	381	31·38	
FeO	8·43		8·54	
MnO	·10	119	·10	565
NiO	·01		·01	
MgO	2·35	58	2·38	
SiO_2	1·28	...	...	
	100·20		100·20	
G	4·34		4·38	
N	...		1·782 ± ·005	

A is the composition of the cleaned concentrate ; B the same, recalculated after rejecting the silica.

Wodgina.—During the mechanical concentration for tantalite of the surface soil on M.L.'s. 86 and 87, several crystals of gahnite have been observed. They are perfect octahedra, with angles typical of the isometric system, and isotropic under the microscope. They vary from 5 to 10 mm. in diameter, are translucent, and of a pale yellowish-green colour. Their uniformly high specific gravity, 4·49, leaves no doubt as to their identity. They have probably been shed from the famous tantalum-bearing pegmatite which traverses these leases.

Gahnite has previously been recorded in the State at Nevoria in a quartz vein, and at Greenbushes and Nannup in alluvial tin concentrates.

* Micros. Det. of the non-opaque Minerals, 1921, p. 17.

(6.) HYPERSTHENE, WARRAMBU, MUR. DIV.

From Warrambu, in the Archæan complex between Mt. Magnet and Sandstone, some detrital specimens of hypersthene of unusual type have been received. They are flat masses about 10 cm. long and 2 thick, and over 4 cm. wide. The original width is unknown as the specimens had been fractured lengthwise before they were examined. Each specimen consists of a single crystal individual with two well-defined cleavages, one parallel to the flat face, the other, also a longitudinal one, practically at right angles to it. On a fresh surface the colour is approximately Ridgway 21[4]k (dark greyish-olive), but on the exposed surfaces the mineral has weathered to a rusty brown.

Under the microscope the prismatic powder is transparent and colourless, and has a straight extinction and positive elongation, with strong birefringence. Measurements of refractive indices by Mr. H. P. Rowledge gave Ng 1·678, Nm 1·664, Np 1·654, all ± ·003. Small brownish stains indicative of incipient oxidation of the iron, penetrate deeply in parts, besides which there are numerous minute inclusions of granular magnetite, as well as of both a green and a colourless amphibole in small fibres and crystals. The total extraneous matter might amount to between 5 and 10 per cent. by weight.

An analysis gave the following figures :—

	Theory.	Warrambu Mineral.		
	$MgFeSi_2O_6$.	%	mols.	
SiO_2	51·82	48·56	808	
Al_2O_3	...	·37	4	53
Fe_2O_3	...	7·83	49	
FeO	30·87	27·24	379	708
MnO	...	·63	9	
MgO	17·31	12·39	307	
CaO	...	·75	13	
Na_2O	...	*nil*	...	
K_2O	...	·08	1	
H_2O+	...	2·19	121	
H_2O-	...	*nil*	...	
TiO_2	...	·18	2	
P_2O_5, CO_2	...	*nil*	...	
		100·22		
G.	...	3·45		
N.	...	1·678, 1·664, 1·654		

Analyst, H. P. Rowledge.

Allowing for the impurities detected by the microscope, and apart from the high water content, the composition might be that of hypersthene, as well as of cummingtonite or anthophyllite. Of these the last two usually contain several per cent. of water, but hypersthene, at any rate in the newer rocks, is usually anhydrous or almost so. Doelter however (H.B. der M.Ch. II., 336) quotes a hypersthene from the Nure Valley (Italy) with 2·78 per cent. H_2O, and one from Kraubat (Austria) with 3·03 per cent., besides several with more than one per cent.

A consideration of the density and optical sign still leaves the same doubt as to classification. The straight extinction in every position however, rules out cummingtonite, which is monoclinic with a maximum extinction of 10° to 20° with the axis of elongation.

A comparison with Winchell's graphs (Elements of Opt. Miner. II., 177 and 204) for the refractive indices of anthophyllite and hypersthene, is not very helpful in coming to a decision, as the following figures show :—

Mineral.	Hypersthene.	Warrambu Mineral.	Anthophyllite.
Per cent. of $FeSiO_3$ mols	40–70	55	40–70
Ng	1·731— ?	1·678	1·667—1·698
Nm	1·729— ?	1·664	1·658—1·690
Np	1·716— ?	1·654	1·650—1·680
Ng–Np	·015—·021	·024 ±	·016—·018

In considering these figures it is to be remembered that those given for hypersthene are for practically anhydrous minerals, and that they would be lower for corresponding compounds with 2 per cent. of water.

Coming finally to the prominent prismatic cleavage, the angle $m^1\ m^4$ in hypersthene is 88°, in anthophyllite 125°, and in Warrambu mineral approximately 90°. One appears therefore to be justified in classifying the last named as a hypersthene with an unusually high proportion of iron oxide and water.

(7.) MAITLANDITE AND NICOLAYITE (Spp. nov.), WODGINA, N.W. DIV.

Under the provisional classification of mackintoshite and thorogummite, the writer first drew attention to two silicates of thorium and uranium found at the north end of the main tantalum bearing pegmatite at Wodgina. This was in the Annual Report of the Geological Survey of W.A. for 1911. This preliminary description was elaborated in Geological Survey Bulletin 48, and in the Journal of the Natural History and Science Society of W.A., Vol. IV., both published in 1912. Since then several other references to the two minerals have appeared in print, the original names being retained up to the present owing to an early doubt as to there being any constant specific differences between them and the original mackintoshite and thorogummite of Texas, which they closely resemble in outward appearance.

Recent investigations of several specimens of each mineral, and a visit to the mine where they occur, have convinced the writer that they are reasonably constant in composition and that the differences between them and the Texas minerals are sufficiently great to be specific. It is proposed therefore, to call the Wodgina " mackintoshite " by the name of maitlandite, in honour of A. Gibb Maitland, Government Geologist of Western Australia from 1896 to 1926, and the first geologist to visit Wodgina and publish a scientific report on its geology and mineralogy.* The other Wodgina mineral, formerly known as " thorogummite," it is proposed to call nicolayite, in honour of the late Rev. C. G. Nicolay who in 1881 started the first permanent collection of minerals in the State, in his capacity of Registrar of Minerals at the newly constituted Geological Museum at Fremantle. His collection was shown at

* G.S.W.A., Bull. 23 (1906).

the Colonial and Indian Exhibition in London in 1886, and later transferred to Perth, where it became the nucleus round which grew the present national collection in the W.A. Museum. In 1881 he wrote "The Handbook of Western Australia" (second edition, 1896) which contained many of the earliest references to the minerals which had been discovered in the State.

The following table gives a comparison of the Wodgina minerals with the Texas minerals.

	Mackintoshite Texas.	Maitlandite Wodgina. A.	Maitlandite Wodgina. B.	Transition Mineral, Wodgina.	Nicolayite, Wodgina.	Thorogummite, Texas.
UO_3	?	traces	traces	29·95	37·33	22·43
UO_2	22·40	35·40	35·60	5·69	*Nil*	*Nil*
ThO_2	45·30	25·86	24·72	24·28	24·46	41·44
SiO_2	13·90	14·62	16·19	n.d.	15·30	13·08
ZrO_2	·88	...	...	...	...	...
Ce_2O_3	...	·10	·10	} ·34	·12	} 6·69
Yt_2O_3	1·86	...	·25	}	·32	}
Fe_2O_3	...	...	...	·32	...	·85
Al_2O_3	...	...	...	...	...	·96
PbO	3·74	6·04	7·90	n.d.	7·78	2·16
FeO	1·15	1·57	·20	n.d.	...	...
MnO	...	...	·07	...	*Nil*	...
CaO	·59	6·02	1·28	n.d.	1·62	·41
MgO	·10	...	·15	...	·16	...
K_2O	·42	...	...	...	...	...
Na_2O	·68	...	...	...	...	...
H_2O+	4·31	n.d.	12·04	10·65	8·37	7·88
H_2O-	·50	n.d.	·88	1·02	4·19	1·23
P_2O_5	·67	...	...	...	...	1·19
$(Ta, Nb)_2O_5$ ...	...	...	·67	...	·40	...
Total	96·50	...	100·05	...	100·05	98·32
G	5·44	4·31	4·45	?	4·13	?
N	1·77 ± ·01	?	?	?	1·617	?

The accepted formulae are :—

Mackintoshite—$3ThO_2 \cdot UO_2 \cdot 3SiO_2 \cdot 3HO_2$.

Maitlandite—$2(Pb,Ca)O \cdot 3ThO_2 \cdot 4UO_2 \cdot 8SiO_2 \cdot 23H_2O$.

Nicolayite—$2(Pb,Ca)O \cdot 3ThO_2 \cdot 4UO_3 \cdot 8SiO_2 \cdot 21H_2O$.

Thorogummite—$2ThO_2 \cdot UO_3 \cdot 3SiO_2 \cdot 6H_2O$.

Mackintoshite and maitlandite are both amorphous, vitreous, and black in colour. They both also consist principally of thorium, quadrivalent uranium, silica and water. They differ however, in that maitlandite contains quite appreciable amounts of calcium and lead, and much more water than mackintoshite, whilst the ratio of thorium to uranium is quite different.

The Wodgina "transition mineral" is a microscopic intergrowth of maitlandite and nicolayite. The analytical figures are of interest in showing the uniform ratio of U to Th, and consistently low figures for Ce and Y in various specimens of these minerals.

Thorogummite and nicolayite are both amorphous, vitreous, and yellow in colour, and consist principally of thorium, sexavalent uranium, silica and water. They are both also derived by weathering, and autoxidation, from the corresponding UO_2 minerals. They differ in that nicolayite contains molecularly important proportions of calcium and lead, whilst the water is higher in the Wodgina mineral. Cerium and yttrium are practically absent from the nicolayite, and quite appreciable in thorogummite, and finally the ratio of $ThO_2 : UO_3$ is quite different.

Neither of these minerals occur in any abundance at Wodgina, in fact only about 50 grammes of maitlandite, and 100 grammes of nicolayite have been collected altogether. By further weathering they pass into pilbarite and finally into hydrothorite.

(8.) OPAL, POONA, MUR. DIV.

An unusual type of opal has been found in a glassy quartz vein on M.L. 94 at Poona. It is bright green in colour (near Ridgway 39'k, dark cinnabar green), the colour being due to the presence of chromium silicate.

The masses reach 2 or 3 cm. in length, and about 1 cm. in thickness, and are distinctly platy in structure, the surfaces of the plates, and parallel partings, being slightly undulating. It is translucent in chips 1·5 mm. thick.

The composition of an apparently homogeneous mass was :

	%	mols.
SiO_2	77·26	1,286
Al_2O_3	·69	7
Fe_2O_3	·37	2
Cr_2O_3	6·41	42
FeO	·14	2
CaO	·46	8
MgO	2·03	50
Na_2O	·06	1
K_2O	·12	1
H_2O+	6·29	349
H_2O-	5·93	329
TiO_2	trace	
P_2O_5	·04	
	99·80	
G	2·14	

Analyst, H. P. Rowledge.

Of the silica 60·24 per cent. was soluble in warm 5% NaOH solution, 17·02 per cent. insoluble.

When the powder is examined under the microscope some fragments are perfectly transparent, homogeneous and isotropic. Many others contain minute films, often parallel, of a highly birefringent mineral, possibly fuchsite. Other plates again have a more unusual structure, containing one or more

isolated or contiguous hexagons outlined by several thin concentric dark lines, formed of minute inclusions, the outermost hexagon being 0·1 to 0·2 mm. in diameter. These hexagonal areas are parallel over restricted areas, and extinguish in opposite pairs of sectors when the plane of polarisation is par llel or perpendicular to the external boundary lines of the sectors. In plain light they are of the same colour and transparency as the rest of the plate (*see* Fig. 15.).

Fig. 15.—Chromiferous Opal, Poona.
x 75.

It would appear that the green platy masses consist largely of opal, pseudomorphous after some hexagonal, or pseudohexagonal, mineral containing chromium, such as stichtite or kammererite. Chromiferous beryl is common in felspathic and quartzose pegmatites at this place, but as beryl is highly resistant to chemical alteration, and is never known to possess an undulating parting, it is hardly possible that this is the parent mineral.

(9.) PSEUDOMALACHITE, COLLIER BAY, KIM. DIV.

Three very closely related basic phosphates of copper have been described in the literature. They are :—

	Cr.	G.	Ng.	Np.	Formula.
Tagilite (Hermann, 1846)	Mc.	4·1	1·85	1·69	$4CuO \cdot P_2O_5 \cdot 3H_2O$
Dihydrite (Hermann 1846)	Tc.	4·2	1·805	1·719	$5CuO \cdot P_2O_5 \cdot 2H_2O$
Pseudomalachite (Haus-mann (1813)	Mc.	4·15	1·807	1·730	$6CuO \cdot P_2O_5 \cdot 3H_2O$ $5CuO \cdot P_2O_5 \cdot 2H_2O$ or $5CuO \cdot P_2O_5 \cdot 3H_2O$

Winchell (1927) describes them all as separate species. Dana (1896) treats each as a separate species, but is doubtful as to the formula of pseudomalachite, and hesitates as to whether it is distinct from dihydrite. Larsen (1921) says pseudomalachite and dihydrite are identical. All three are usually found in green fibrous masses in the outcrops of copper lodes.

In the Collier Bay District (West Kimberley) a few specimens of highly phosphatic copper ore have been found, in which the phosphorus is present as one or other of the above minerals. A bulk parcel of ore contained 9·46 per cent. of P_2O_5 and consisted of a mixture of quartz, pseudomalachite and chalcocite with a little limonite and malachite. A small fragment of the purest phosphate (which was distinguishable by its ready solution in dilute acid without effervescence) contained 22·34 per cent. of P_2O_5. It was impossible to collect more than a fraction of a gram of this material, but several grams of the purer phosphate were handpicked and analysed with the following results :

		%
Insol. in cold dil. HCl	SiO_2 (quartz)	1·95
	Cu } Cu_2S	11·54
	S } Cu_2S	2·91
Sol. in cold dil. HCl	CuO	56·15
	Fe_2O_3	·47
	CaO	trace
	P_2O_5	18·47
	As_2O_5	*nil*
	CO_2	1·60
	H_2O+	7·28
	H_2O-	·07
		100·44
	Sp. gr.	4·18

After deducting quartz, chalcocite and limonite, the recalculated results are :—

	Per cent.	Total Mols.	Mala-chite.	Mols left.
CuO	67·27	845	88	757
P_2O_5	22·12	156	...	156
H_2O	8·69	483	44	439
CO_2	1·92	44	44	...
	100·00			
Sp. gr.	4·08			

After deduction of probable malachite, the molecular ratios of the phosphatic mineral are :—

CuO	...	...	5·01
P_2O_5	...	...	1·03
H_2O	...	...	2·90

This is very close to $5CuO \cdot P_2O_5 \cdot 3H_2O$, Dana's alternative formula for pseudomalachite, which may also be written $Cu_5(OH)_4 (PO_4)_2 \cdot H_2O$.

The Kimberley mineral is in dense masses of a "nickel green" colour (Ridgway 37″ k) with a small botryoidal surface. Where the mineral is less compact the green colour is much lighter, varying from the above to about "Montpellier green" (37″).

(10.) RIEBECKITE, HAMERSLEY RANGE, N.W. DIV.

The existence of "blue asbestos," *i.e.* fibrous riebeckite, in the range known at one end of its 300-mile length as the Hamersley, at the other as the Ophthalmia Range, has been rumoured for many years. The writer was shown specimens over 20 years ago, and in 1917 H. P. Woodward and A. Montgomery in a Mines Department Pamphlet* stated:

> "Blue asbestos of good quality and very strong fibre has been found in the North-West, and according to one prospector's report is in very large quantity. No official examination of the discovery has yet been made, however."

Again, in 1922, R. C. Wilson wrote†:

> "Specimens of crocidolite, said to have come from the Hamersley Ranges, have been exhibited in Perth, but no deposit has yet been officially examined."

Little credence has been given to these reports in the past, as no official inspection has ever been made of any of the reported deposits, which were in very inaccessible localities, and as it was known that occasional specimens of South African blue asbestos had been brought to the State many years ago, and later the same mineral had been imported in bulk for manufacturing purposes.

During this year, however, reports and specimens have been received at firsthand from trustworthy sources, and these show that typical blue asbestos of excellent commercial quality has been located at several points within a few miles of Mt. Margaret (Lat. 21° 58′, Long. 117° 50′) towards the western end of the range, and at one, if not more, points near Willi-Wolli Springs (Lat. 22° 53′, Long. 119° 15′) towards its eastern end. None of the deposits has been seen by any official of the Mines Department, but Mt. Margaret itself, and other parts of the range have been geologically examined in the past.‡ The whole of the range, from Mt. Margaret to Willi-Wolli consists of bedded rocks of the Nullagine series (late Precambrian ?), including sandstones, shales, limestones, jasperoids and lava flows, with occasional exposures of early Precambrian igneous rocks and schists in the deepest gorges and in the flanks of the range. In both areas the riebeckite appears to be associated with the jasperoids, which H. W. B. Talbot considers§ to be local variations of Nullagine shales or related rocks.

Mt. Margaret.—Specimens from this area show fibrous blue asbestos filling veins varying in width from 1 mm. to 4 cm. (0·04 to 1·5 inches). The enclosing rock is a banded siliceous ironstone, in which limonite is prominent, whilst narrow bands of granular magnetite are seen close to the asbestos veins. The veins are parallel to the bedding, whilst the asbestos fibres are at right angles, or almost so, to the walls. There is no break of the fibres in the centre of the veins as is so often seen in chrysotile veins.

In mass the colour of the mineral is indigo blue (Ridgway 47″ m) to Tyrian blue (47″ i) with very low translucency. As the mineral is disinteg-

* The useful Minerals of W.A., p. 28. † A. R. Geol. Surv. W.A., 1921, p. 41.
‡ G.S. Bull. 33, pp. 119, etc.; G.S. Bull. 83, pp. 100, etc. § G.S. Bull. 83.

rated, it pales through all tints to about pearl blue (49″ f). The masses are very easily teased out, yielding a very fine, soft, highly flexible and tough fibre. Individual fibres have a diameter of one micron or less, and small bundles have a negative elongation. Owing to the strong absorption parallel to the length it was impossible to obtain a close reading of the maximum extinction angle, but it appears to be 6° or slightly less for Na light. The pleochroism is always indigo blue parallel to the length, and lighter blue or yellowish-green at right angles thereto. The birefringence is low.

The compositions of typical unweathered specimens from 3 miles West of Mt. Margaret, and from 8 miles S.E. of Willi-Wolli Springs are given below, together with a recent analysis of a similar mineral from Kuruman, Bechuanaland.*

	Mt. Margaret.		Willi-Wolli.		Kuruman.
	%	Mols.	%	Mols.	%
SiO_2	51·86	863	51·94	864	50·50
Al_2O_3	·03	127	·24	121	...
Fe_2O_3	20·26		18·93		20·20
FeO	14·84	296	15·25	317	15·40
MnO	·01		·01		...
MgO	3·26		3·94		3·65
CaO	·49		·40		·80
Na_2O	6·12	102	6·00	99	4·40
K_2O	·28		·26		...
H_2O+	1·97	109	2·67	148	4·15
H_2O-	·68		·72		1·05
TiO_2	·03		·01		...
CO_2	·02		*nil*		...
P_2O_5	·05		*nil*		...
Cr_2O_3	*nil*		*nil*		...
	99·90		100·37		100·15
G	3·31		3·27		..
Analyst—	J. N. Grace.		J. N. Grace.		J. McCrae.

Excess silica and water over theoretical requirements appear frequently in analyses of asbestos of all kinds. This may be due to thin films of talc or opal on the surface of the fibres. The calculated excesses by weight in these two cases are SiO_2, 3·54 and 3·78 per cent; H_2O, 1·42 and 2·27 per cent. Deducting these, the analyses, in terms of known and assumed isomorphous molecules, prove to be:

	Mt. Margaret. mols. per cent.	Willi-wolli. mols. per cent.
$NaFe'''(SiO_3)_2$	50·8	49·5
$Fe_2''(SiO_3)_2$	36·8	39·5
$HFe'''(SiO_3)_2$	12·4	11·0
	100·0	100·0

Some authors consider the Fe_2O_3 here calculated as $HFe''' Si_2O_6$ to be present as isomorphous Fe_2O_3, i.e. (Fe_4O_6), which does not appear probable to the present writer, and would leave a still larger excess of silica and water to be explained.

* J. Ch. Met. Min. Soc. S. Af. 27, 287.

Willi-Wolli.—Specimens from a gorge eight miles S.E. of these springs are practically identical with those from Mt. Margaret, 100 miles distant. The enclosing rock is again a banded quartz-limonite jasperoid with strings of granules of magnetite, particularly against the ends of the asbestos fibres. The riebeckite is of the same indigo-blue colour, translucent only in fractions of a millimetre. The veins are somewhat wider, yielding fibre up to 5 cm. (2 inches) in length. It teases out readily to very fine, soft, highly flexible and tough fibres. Its composition has already been given.

Some of the specimens found as loose boulders in the valley have a thin crust of rusty decomposition products on them. These, however, do not penetrate far into the masses.

This is the first record of commercial crocidolite (fibrous riebeckite) in Australia.

3.—CONTRIBUTIONS TO THE FAUNA OF ROTTNEST ISLAND.

No. VI.

NOTES ON THE ODONATA AND NEUOPTERA.

By W. H. Mathews.

(Communicated by L. Glauert, March 11th, 1930. Published 24th July, 1930.)

Up to the present little has been done in the way of collecting Neuopterous insects on the Island, and these notes have been prepared with a view of attempting to increase the interest in this most interesting group of insects, which include archaic as well as highly developed types.

Order—**ODONATA.**

Suborder—**Anisoptera.**

Family—AESCHNIDAE.

Aeschna brevistyla, Ramb.—This is one of our largest Dragon-flies, and is a species of the tropical genus *Austrogymacantha*. It is abundant throughout Australia except in the tropics, is common in Tasmania, and is the only known Aeschnid in New Zealand. This family contains the true hawking dragon-flies, distinguished by their large size, their usually conjoined eyes, their wings with the triangles closely similar and both elongated in the direction of the wing axis. The males have the anal angle of the hindwing angulated, females always with well developed ovipositor. The larvae are of a very characteristic shape and are the largest to be found in our pools and streams: they have a long flat mask with a strong movable hook. I have kept these larvae in captivity for as long as three years and have observed how they stalk their prey with great cunning and fearlessness, even attacking tadpoles much larger than themselves, and when once they get a grip they hang on with bull-dog tenacity.*

Family LIBELLULIDAE.

Subfamily Trameinae.

Trameа limbata, Desj.—The Trameinae contain the most highly evolved of all dragon-flies and are either tropical or sub-tropical. *T. limbata* is certainly the most handsome representative of all of our dragon-flies; the large fulvous patch in the anal field of the hind wing serves as a means of identity at a glance. This is also one of, if not the most, shy of these insects, and if missed by the first sweep of the net they generally rise to a great height and dart away at a high speed. I have in my collection a specimen that was taken in Gage Roads more than a mile from land.

* *Anax papuensis, Burm.*, was taken on the island in April, 1930.—L.G.

Subfamily Libellulinae.

Orthetrum caledonicum, Brau.—This is one of the most common of our dragon-flies, and can be seen almost anywhere near the river; it has a great habit of resting on small pebbles on the footpath. The sexes are very dissimilar, the male, when mature, being covered with a pale blue pruinescence; the female is yellow and black and might be taken for a different species.

Subfamily Sympetrinae.

Diplacodes bipunctata, Brau.—Is abundant in Australia, is not found in Tasmania, and is the only Libelluid found in New Zealand. The male is dull red with black spots on the abdomen, the female is yellowish-brown; these are amongst the smaller species of dragon-flies, and are quite common around most of our streams and pools. I have taken them around Perth, in the hills, and as far south as Bunbury.

Subfamily Leucorrhiniinae.

Austrothemis nigrescens, Martin.—A very handsome and rather rare dragon-fly, found chiefly in Tasmania and W.A. The abdomen is club-shaped; in the male it is coloured bright red and black and in the female yellow and black. At rest it has a very characteristic attitude, with the wings thrown forward of the thorax; it is very shy, and must be taken with a quick sweep of the net, as no second opportunity will be given if not taken by the first sweep. I have taken them as far south as Bunbury, also at South Perth. The larva is unknown.

Family CORDULIIDAE.

Hemicordulia tau. Sel.—This genus, of which *H. tau* is the commonest, has its headquarters in Australia and belongs to the group which marks the highest point yet reached in the order. *H. tau* can be identified by the olive green colour of the back of the abdomen and the black T mark on its pale yellow frons, from which it derives its name. Dr. Tillyard says it occasionally swarms in great numbers and appears to travel a long distance, though not yet recorded at sea. It has, however, recently (1917) colonized Tasmania across straits 200 miles wide. It is common around Perth.

Sub Order **Zygoptera**—(Damsel Flies).

With few exceptions, the members of this sub-order rest with their wings folded back above the abdomen ; the larvae are slender in build and breathe by means of three leaf-like, caudal gills, situated at the end of the abdomen, though this does not seem to be their only means of breathing, for I have, more than once, seen specimens which have lost their gills live and mature. A peculiar fact noticed on Rottnest Island is that, though usually inhabiting fresh water, there they were found in water of great salinity. Dr. Tillyard says " the larvae have been known to withstand a salinity up to a density of 1·01 (sea water 1·026), but at that point the larva could live, but not undergo metamorphosis." I have not actually seen the metamorphosis take place at Rottnest, but from the fact that the larvae were living in the salt water, and the imagines were flying in numbers, whilst there was an entire absence of fresh water, I think it most probable that these insects had reached full maturity in the exceedingly salt water there.

Three species of this sub-order were taken.

Family LESTIDAE.

This is a world-wide family represented in this country by the genus *Austrolestes;* most of the species are bronze and blue, and the wings expand about two inches.

Austrolestes analis. Ramb.—Is a very common insect, and is found over the greater part of Australia; it is very variable both in size and colouring, immature specimens have a pinkish colour, the mature insect being pale blue.

Austrolestes psyche. Selys.—A somewhat smaller insect than the former, also common to the greater part of the Southern half of the continent, the abdomen being more or less blue with a black or bronze dorsal mark. Both of these insects breed in still water and are rarely, if ever, found in running water; they are essentially inhabitants of the swamps.

Family COENAGRIIDAE.

Ischnura aurora. Brau.—This is one of our smallest and most brilliant species; the male has a red abdomen tipped with bright blue, and the contrast is very striking. It appears most handsome as it hovers in the sun amongst the rushes on the edge of a waterhole or swamp; the female is much quieter in colour, being of a uniform bronze green. I have seen these in great numbers as far south as Bunbury; they are also common around Perth.

References :—

Tillyard, R. J.—"Insects of Australia and New Zealand."

do. "The Dragonflies of S.W. Australia," Proc. Linn. Soc. N.S.W., xxxii.

do. "Life history of Lestes leda, Selys." Proc. Linn. Soc. N.S.W., xxxi.

do. "The Biology of Dragonflies."

Order **NEUROPTERA.**

Suborder **Planipennia.**

Family MYRMELEONTIDAE.

Myrmeleon uniseriatus, Gerst.—The larva of this insect is a pit-forming "ant-lion." Their pits are very common in the bush, particularly in the fine sand at the base of large trees; the cocoon is spherical, composed of grains of sand woven in with the silk, and is placed at the bottom of the pit. This is one of our commonest and plainest lacewings, is found right through the S.W. portion of the State, and occurs as far north as Queensland. The triangles of the fore wings are composed of simple cells.

Acanthaclisis fundata. Walk.—The larva of this species does not build a pit, but travels about just under the surface of the ground with eyes and strongly toothed jaws exposed; it usually progresses backwards, and on clear sandy patches in the bush its tracks can often be seen, particularly in the morning, as it is mostly nocturnal in its wanderings. The cocoon is similar to that of *M. uniseriatus*, only larger, and is placed about two or three inches

underground; the pupa emerges from the cocoon and works its way to the surface, where it remains with the head and thorax exposed; the skin splits down the back and the imago emerges, leaving the exuvia sticking in the sand. This species has a double row of cells throughout the costal space of the forewing, and is a very handsome insect with a hairy body and densely reticulated wing venation.

Reference :—Tillyard, R. J.—"Insects of Australia and New Zealand."

Note.—The Order Trichoptera is represented by one species of Caddis-fly, not yet identified, but which Dr. Tillyard believes is a new species of Triplectides. The Doctor is now waiting further material to determine and describe this insect. This is of exceptional interest, from the fact that the larva lives in the salt lakes and makes its case of silk covered with grains of sand, in a tubular form; the remarkable fact is that most of this order lives in fresh water, and are vegetable eaters, but this species has evidently adapted itself to water the salinity of which is much greater than the ocean itself.

4.—Notes on

A COLLECTION OF BEES FROM WESTERN AUSTRALIA.

With 2 Plates, Nos. V. and VI.

By Tarlton Rayment.

(*Read, 8th April*, 1930, *Published 24th July*, 1930).

Mr. Tom Greaves, the honorary secretary of the Victorian Entomological Club, has submitted to me a number of specimens which he collected in Western Australia. The interesting character of the new bees is sufficient justification for the publication of the descriptions. The balance of the material will form the basis of another paper.

Division **COLLETIFORMES.**

Family PROSOPIDIDAE.

Euprosopis elegans (Smith).

These beautiful black red and yellow bees were first described from Adelaide by Fred Smith, (1) as *Prosopis elegans*. Doctor Perkins, (2) erected the genus *Euprosopis*, which includes four forms, *E. elegans* (Smith), *E. elegans huseloides* Ckll., *E. husela* Ckll. and *E. nodosicornis* Ckll.

Professor Cockerill, (3) described the male of *Prosopis sydneyana*, and in June (4) he published the specific description of another male, *Prosopis rollei*. Three months later, he again referred to these elegant bees, and evidently felt some misgivings, for he said :—" *P. rollei* is readily separable from *elegans* in the male, but it may be that females at present ascribed to *elegans* belong in part to *rollei*."

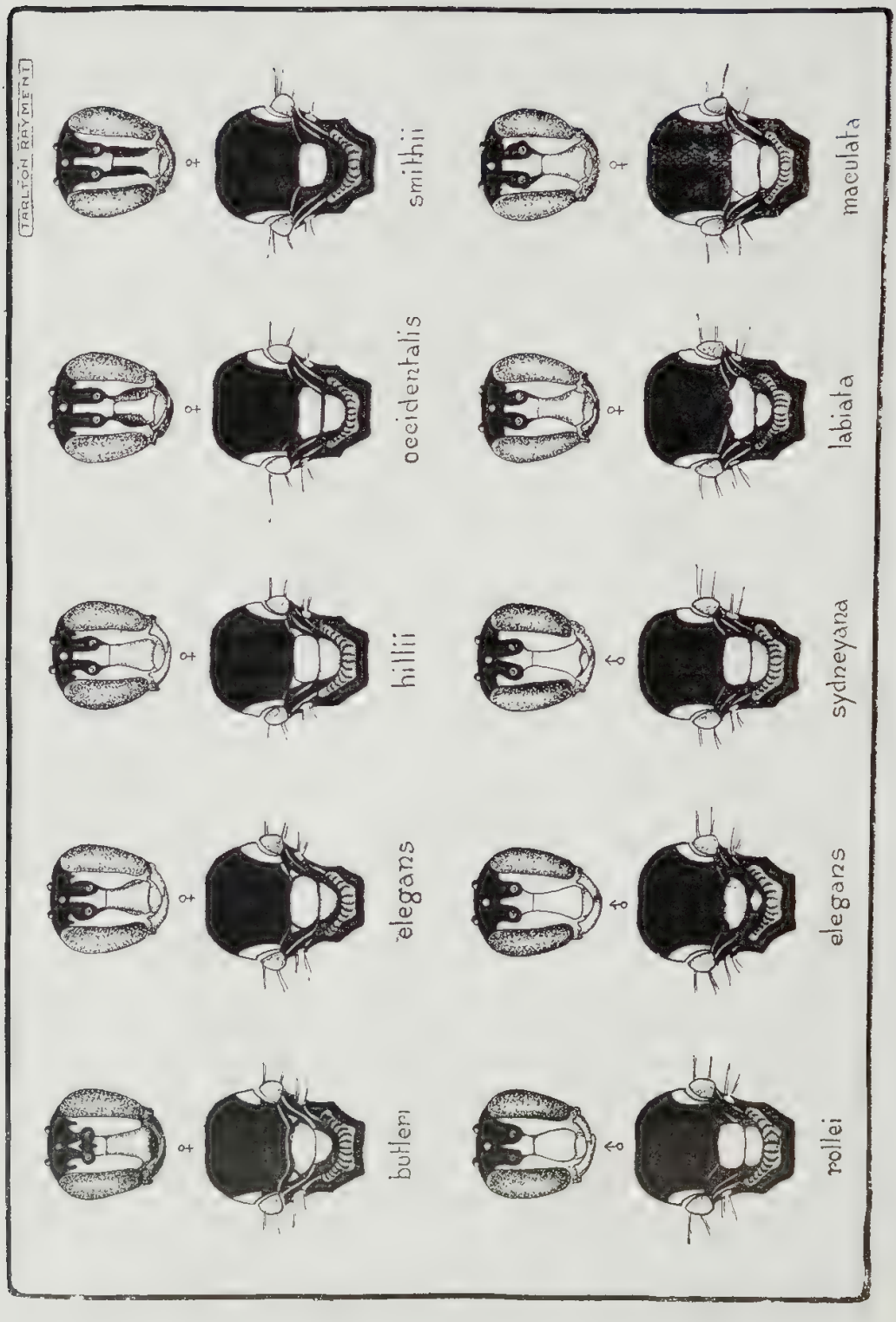
Smith's description seems to indicate that the three yellow face-marks are truncated almost at the level of the median ocellus ; the truncation is not a straight line, but is toothed, and the specimen (No. 6 in the table), identified by Professor Cockerill, seems to conform to the original description, which does not include any yellow marks near the tubercles, nor lateral spots on the scutellum.

There is a departure from the type in size, and colour, but not in sculpture ; a slight colour variation is found in the red of the abdomen. I think that most of the reddish tint observed on the legs is due to the chemical change effected by the hydrocyanic gas of the killing-bottles.

I have now a large series of these bees, collected by various people over a wide range and, recently, I received additional material which had been taken at Bungulla, on the Transcontinental Railway. I have also studied numerous specimens in the Melbourne Museum, and am able to separate several varieties. It seems very improbable that Smith had the sexes of *elegans*.

Ararat and Macedon, though miles apart, are both situated in the main mountain range of Victoria, enjoying much the same class of climate, and it is more than probable that variety *butleri* will prove to be the true female of *E. rollei*. The table will assist students to separate them.

PLATE V.


TARLTON RAYMENT
butleri
elegans
hillii
occidentalis
smithii
rollei
elegans
sydneyana
labiata
maculata

1. *Female* 10 *mm.*

Light yellow mandibles and labrum ; large lateral spots on scutellum ; no yellow crescent near tubercules : an exceedingly fine line of reddish-amber separating the face-marks from the clypeus ; antennae bright orange throughout ; abdomen black, a few obscure red patches, hind margins of segments amber. Pterostigma almost colourless.

Horse-shoe Bend, Finke River, Central Australia (G. Hill.)

New variety *hillii.*

2. *Female* 8 *mm.*

All yellow face-marks reach to level of median ocellus, laterals terminate with a point, the median one is truncated ; reddish-amber mandibles and labrum ; small lateral marks on scutellum ; a long wide yellow epaulet ; no yellow crescent near tubercles ; a wide line of blackish amber separating face-marks from the clypeus ; scapes yellow, flagellum reddish-amber beneath, blackish above ; abdominal segments, one red, with large median black patch, two red, with a narrow black patch apically, three black, with red patch laterally, four, five and six black. Pterostigma dark amber.

Sandringham, Port Phillip, Victoria. (Rayment, February, 1929).

New variety *maculata.*

3. *Female* 11 *mm.*

Two yellow face-marks almost to level of median ocellus ; Supraclypeal mark small, bidentate at apex, a small cuneiform mark above ; a fine line of amber separating the face-marks ; labrum blackish-red, mandibles reddish-amber ; scapes reddish-amber ; flagellum reddish beneath, blackish above ; a short sub-triangular epaulet ; large lateral spots on scutellum ; sub-triangular marks near tubercles similar in size and shape to epaulet ; abdominal segments, one and two red, hind margins narrowly darker, three red, black basally. Legs reddish-amber. Pterostigma blackish-brown.

Mount Macedon, Victoria. (Butler, 27th November, 1927).

New variety *butleri.*

4. *Female* 10 *mm.*

Three yellow face-marks truncated at level of median ocellus ; a long hastate black mark separating face-marks from clypeus ; labrum yellow ; mandibles reddish-amber ; scapes yellow ; flagellum reddish-amber beneath, blackish above ; no small lateral spots on scutellum ; a long wide epaulet ; no yellow mark behind tubercles. Abdominal segments, one, two and three with obscure red laterally, three, four, five and six black.

Bungulla, Western Australia (Tom Greaves, October, 1929).

Hampton, Victoria (S. Chidgey, 7th December, 1929).

New variety *occidentalis.*

5. *Female* 10 *mm.*

Similar to 2, but has a yellow labrum, and all the face-marks are truncate at apex.

Mt. Yule, Healesville, Victoria. (R. Kelly, 26th February, 1914).

New variety *labiata.*

6. *Female* 7·5 *mm.*

Similar in colour and structure to 2, but has yellow labrum and mandibles, and no yellow spots, laterally, on scutellum ; apex of face-marks bidentate. Pterostigma lighter, with narrow dark margin.

Fern Tree Gully, Victoria (F. Spry, no date).

Bungulla, Western Australia. (Tom Greaves, October, 1929).

Identified by Professor Cockerell as *E. elegans* (Smith.)

7. *Male* 6 *mm.*

Three face-marks terminating with sharp points at level of median ocellus ; labrum yellow, mandibles yellow ; scapes dilated, yellow, flagellum yellow beneath, reddish-amber above ; no lateral marks on scutellum ; long narrow epaulet ; no yellow mark near tubercles. Abdominal segments, one red, with median black patch, two red, three black, with large lateral red patches, the others black. Pterostigma pale amber, dark narrow margins. Probably true male of *E. elegans.*

Broadmeadows, Victoria. (F. Spry, 31st January, 1920).

Bungulla, Western Australia. (Tom Greaves, October, 1929).

8. *Male :*

Similar to 6, but with postscutellum black. Abdominal segments one and two red, with a median black line, the others blackish. Adelaide, South Australia (type locality).

Described by Smith as *Prosopis elegans.*

It is better to regard this as variety *smithii.*

9. *Male* 6·2 *mm.*

Three pointed yellow face-marks reaching almost to level of median ocellus ; mandibles and labrum yellow ; antennae bright ferruginous ; tubercles, tegulae, scutellum, and a spot on the postscutellum, all ferruginous (probably reddened with cyanide). Legs bright ferruginous suffused with yellow. Pterostigma pale.

Ararat, Victoria. (Rolle).

Described by Professor Cockerell as *Prosopis rollei.*

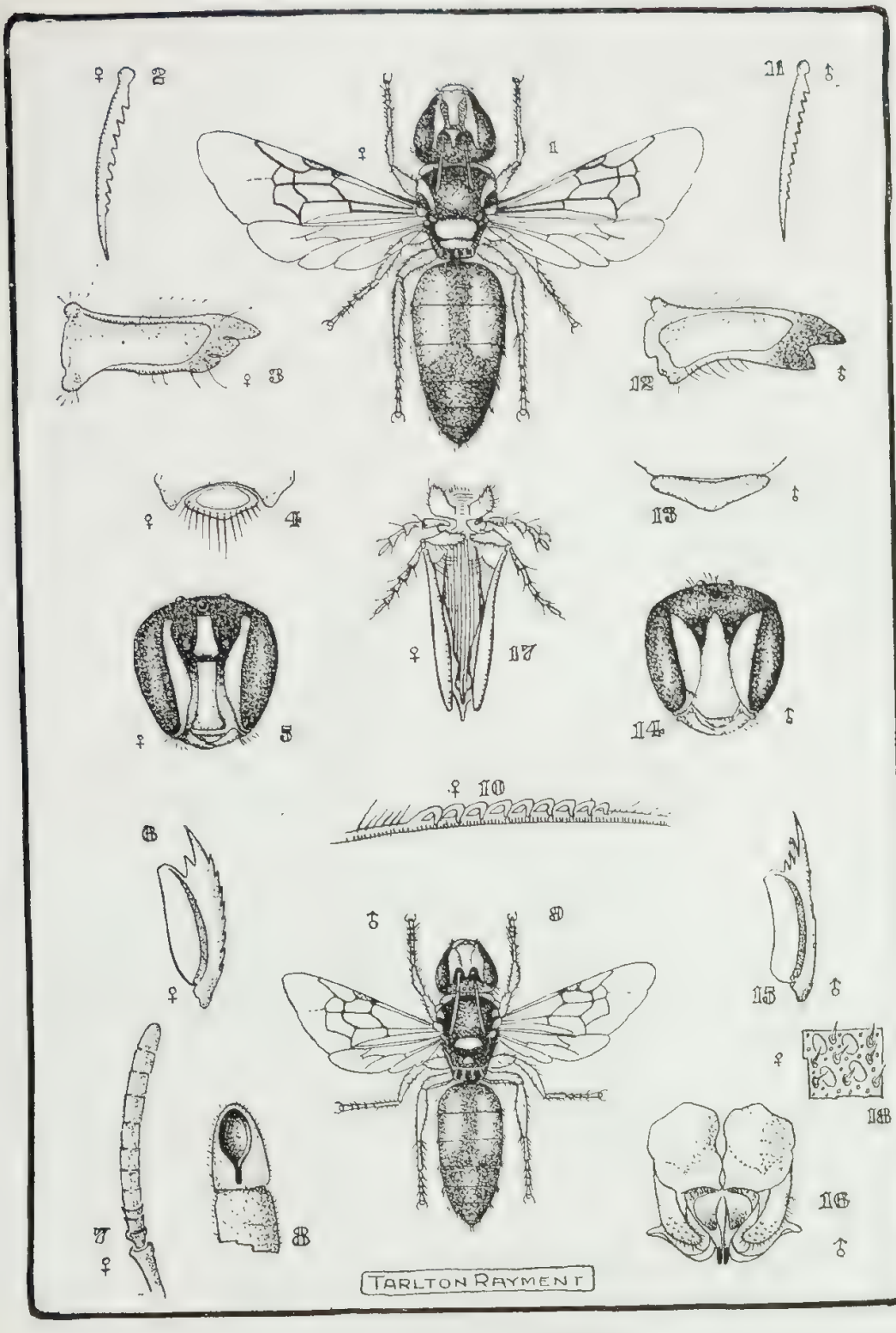
10. *Male* 6 *mm.*

Three yellow face-marks reaching to level of median ocellus, the median one gradually narrowing, the lateral ones truncated ; scape yellow, swollen, flagellum light ferruginous beneath, darker above ; labrum and mandibles bright chrome-yellow ; cheeks entirely black (all others with reddish patch on genae) ; scutellum and postscutellum yellow.

Sydney, New South Wales (W. W. Froggatt, 1891).

Described by Professor Cockerell as variety *sydneyana.*

PLATE VI.



EXPLANATION OF PLATE.

1. Adult female of Euprosopis elegans (Smith). 2. Hind calcar of female. 3. Mandible of female. 4. Labrum of female. 5. Front of head-capsule of female. 6. Strigil of female. 7. Antenna of female. 8. Small smooth cavity in apical joint of flagellum. 9. Adult male Euprosopis elegans. 10. Hamuli of female. 11. Calcar of male. 12. Mandible of male. 13. Labrum of male. 14. Front of head capsule of male. 15. Strigil of male. 16. Genitalia. 17. Glossa and palpi of female. 18. Pore and peg organs of antenna of female.

Family **COLLETIDAE.**

Paracollettes albo-pilosa (new species.)

Male—Length, 10 mm. approx.

Head wide, bright, black, with white hairs ; face-marks nil, dense covering of white hair ; Frons densely covered with punctures of medium size dull-white hair ; Clypeus with numerous coarse punctures, bright, and covered with silvery white hair ; Supraclypeal area similar to clypeus ; Vertex with thin black hair ; Compound Eyes converging below ; Genae coarsely punctured, bright, with much silvery hair on lower half ; Labrum black ; Mandibulae black, obscure red apically ; Antennae submoniliform, black.

Prothorax not visible from above, pleura with long white hair ; Tubercles with black hair ; Mesothorax with numerous coarse punctures, shining and smooth between, black hair, a few white hairs along anterior margin, black ; Scutellum similar to mesothorax, with white hair on posterior margin ; Postscutellum similar to scutellum ; Metathorax with a small subtriangular area with transverse striae, the remainder having dense vermicular rugae ; Abdominal dorsal segments densely covered with punctures of medium size, black, bright ; thin bands of white hair on bases of segments one, two and three, anal fimbria black ; Abdominal ventral segments black, with some white hair.

Legs black, with white hair ; Tarsi black with white hair ; Claws black ; Hind calcariae finely serrated, blackish ; Tegulae black, shining ; Wings hyaline, iridescent, anterior 6 mm. ; Nervures blackish, basal just short of nervulus, first recurrent entering second cubital cell at middle ; Cells second small cubital contracted at apex into a pentagonal figure ; Pterostigma extremely narrow, black ; Hamuli nine in number, of moderate development.

Locality, Perth, W.A. (Tom Greaves), 14th October, 1929.

Allies : *P. punctatus* Smith, which has dull-white hair on face, dirty white hair on vertex, testaceous antennae, distant punctures on mesothorax with ochreous hair, legs rufo-piceous with fulvous hair, nervures testaceous. *P. incanescens* Ckll, which has shallow punctures on mesothorax, and some chestnut-red on the legs, nervures fusco-ferruginous. *P. cinereus* Smith, which has wings clouded at apex, and fringe of white hair on segments of the abdomen. *P. argentifrons* Smith, which has anterior tibiae and tarsi, and fifth tarsus of other legs, ferruginous.

Type in the collection of the author.

Paracolletes plumosella Ckll.

One male conforms very well to Professor Cockerell's description of this species in the length, 7½ mm., and the colour, metallic green on head and thorax, with a dark purple abdomen, but the long dull white hair on the frons is mixed with dusky, and the legs are darker, the red being most obscure.

Professor Cockerell thought that *plumosella* might prove to be the male of *plumosa* SMITH, but I have close to my home a sandy bank housing a large colony of this species, and have caught numbers of both sexes at the burrows. The male of *plumosa* is larger than *plumosella*, and the richer purple of the abdomen is much more highly polished.

Only the male of *plumosella* has been described, and this is rather surprising, as the female must be brightly coloured, and it is not a small species. I shall shortly review the collection of the West Australian Agricultural Department, and fully expect to identify the female *plumosella*.

Perth, West Australia, October, 1929. (Tom Greaves).

Division **ANDRENIFORMES.**

Family ANDRENIDAE.

Subfamily Halictinae.

Halictus (Chloralictus) occidentalis (new species).

Female—Length, 5·5 mm. approx.

Head wide, very minutely striate, a brilliant coppery iridescence, a few short white hairs ; Face-marks confined to two small smooth blackish patches at bases of anterior orbital margins ; Frons minutely striate ; Clypeus convex, with coarse scattered punctures, purplish black, iridescent, the posterior edge of reddish-coppery iridescence ; Supraclypeal area with coarse punctures, iridescent copper ; Vertex with black ocelli on a slight prominence ; Compound Eyes converging above and below, blackish-claret ; Genae with numerous appressed short white hairs ; Labrum reddish-amber ; Mandibulae cream-coloured, black basally, reddish apically ; Antennae submoniliform, clear ferruginous beneath, slightly darker above.

Prothorax not visible from above ; Tubercles butter-yellow, with a black spot, and fringed with short white hair ; Mesothorax with numerous fine punctures, cancellate, a few short white hairs, a brilliant metallic olive green—not so coppery as head ; Scutellum polished, scattered coarse and fine punctures, more coppery than mesothorax ; Postscutellum with punctures closer together, darker, duller, a few white hairs ; Metathorax with a wide lunate area, but no rim, a fine scale-like sculpture, superimposed basally are a few coarse anastomosing rugae which run out medianly and laterally as transverse striae ; Abdominal dorsal segments clear chestnut-red, shining, a few white hairs laterally ; Abdominal ventral segments darker, with a scopa of curled white hair, laterally blackish spots.

Legs clear ferruginous, knees creamy-yellow, whitish hair; Tarsi slightly darker ; Claws paler ; Hind Calcariae pale, with two long strong teeth ; Tegulae translucent, shining, very pale amber, with a dark spot, axillae pale ; Wings hyaline, very iridescent, anterior 4 mm. ; Nervures basally are palest amber, apically a darker amber, second recurrent and third intercubitus extremely faint ; Cells : radial rather large, the second and third cubitals greatly contracted at apex ; Pterostigma dark amber with a narrow dark margin ; Hamuli seven, of weak development.

Locality : Perth, W.A. (Tom Greaves). Date, 19th October, 1929.

Allies : *H. tarltoni* Ckll, which has a blackish head and tubercles ; *H. raymenti* Ckll, which has a black patch on basal segment of abdomen ; *H. doweri* Raym, which has anastomosing rugae over entire area of metathorax, and one long tooth on the hind calcar. This may be near to *H. vitripennis*, Smith, but that author's description is altogether too meagre.

Type in the collection of the author.

Paratype in the W.A. Museum.

Halictus brazieri—Cockerell.

Two females, quite typical, were received, but owing to several bees having been sent in one capsule, I may not have the localities correctly. They came either from Perth or Denmark, I think the latter. October, 1929. (Tom Greaves).

Previously recorded from Kalamunda.

Specimens sent to W.A. Museum, Perth.

Halictus chapmani—Cockerell.

Eight females, typical in form and colour, but the transverse ridges on the anterior portion of the mesothorax of the type are inconspicuous on these specimens.

Denmark, W.A., October 26th, 1929. (Tom Greaves).

Previously recorded from "Western Australia."

Specimen sent to the Museum, Perth, and also to the Agricultural Department, Perth.

I obtained a few Acarid mites from the thoraces of these bees and, later on, will publish a paper on the incidence of the Acarids in diseases of the honey-bee.

Halictus (Chloralictus) formosus (new species.)

Female—Length, 6 mm. approx.

Head wide, a beautiful iridescent emerald-green with coppery sheen ; Face-marks two small smooth blackish marks at bases of orbital margins ; Frons large, longitudinally striate, with scattered punctures along the grooves ; Clypeus convex, smooth, anterior half brilliant blackish-purple, coarse punctures, anterior edge depressed ; Supraclypeal area iridescent green, no striae, a few punctures ; Vertex has transverse striae, and a few pale hairs ; Compound Eyes blackish-brown, converging at base and apex ; Genae closely striate, with a few light hairs ; Labrum black ; Mandibulae black, obscurely red apically ; Antennae black, the scapes being very long.

Prothorax not visible from above, mesopleura finely rugose, with long pale hair ; Tubercles black, with a fringe of drab hair ; Mesothorax with a delicate tesselate sculpture, numerous punctures of medium size, a brilliant iridescent green, with a narrow purple margin laterally ; Scutellum similar to mesothorax in colour and sculpture ; Postscutellum darker iridescent green, with anastomosing rugae ; Metathorax large, a wide lunate area with coarse anastomosing rugae, brilliant iridescent green, a fringe of golden hair ; Abdomen with dorsal segments a polished blackish bronze, hind margins broadly depressed, a few pale hairs at the apex ; Abdominal ventral segments granular, with a few white hairs.

Legs slender, black, with obscure red tints, pale hair ; Tarsi amber, hair yellowish ; Claws reddish ; Hind Calcariae with three long strong rounded teeth, amber ; Tegulae amber, black basally and anteriorly ; Wings subhyaline, iridescent, anterior 4·8 ; Nervures brown, the third intercubitus and second recurrent slightly weaker ; Cells normal for the genus ; Pterostigma dark brown ; Hamuli seven in number, weakly developed.

Locality, Albany, W.A. (T. Greaves). 23rd October, 1929.

Allies : *H. callaspis* Ckll. which has bluish tints on the mesothorax and, reddish tints on the abdomen, and is not so robust.

H. formosus has a superficial resemblance to *H. demissus* Ckll, which is duller, and has a black metathorax with radiating rugae.

Type in the collection of the author.

Halictus (Chloralictus) greavessi, new species.

Female—Length, 4·5 mm. approx.

Head slightly wider than thorax, longitudinally striate, a brilliant coppery green, a few white hairs ; Face-marks nil ; Frons with a number of punctures between the striae ; Clypeus with a median depression, a few coarse punctures, blackish purple, extremely iridescent ; Supraclypeal area convex, metallic purple ; Vertex with wine-red ocelli in a low curve ; Compound Eyes slightly converging above, dark claret colour ; Genae iridescent green, with numerous white hairs ; Labrum amber ; Mandibulae amber, with dark tips ; Antennae with long black scapes, flagellum fulvous beneath, blackish above.

Prothorax not visible from above ; Tubercles dark iridescent green, fringed with short white hair ; Mesothorax evenly punctured, a minute shagreen sculpture, a dull iridescent coppery-green ; Scutellum brilliant bluish green ; Post scutellum rough, blackish iridescent green ; Metathorax with numerous coarse rugae, partly radiating, inside a lunate band of fine striae, the whole area of a brilliant iridescent green ; Abdomen : dorsal segments dull chestnut-red, hind margins broadly lighter, one a brilliant, metallic bronze, with broad red margin, a few short white hairs ; abdominal ventral segments reddish, with white hair.

Legs chestnut-red, with scanty white hair, coxae, trochanters and femora basally dark ; Tarsi paler, with yellowish hair ; Claws pale amber ; Hind Calcariae with one long rounded tooth, and a low wide wave-like one beyond ; Tegulae and axillae pale amber ; Wings iridescent, slightly iridescent anterior 2·6 mm. ; Nervures pale amber, first recurrent entering apical fourth of second cubital cell, second recurrent and third intercubitus slightly weakened ; Cells : second cubital contracted at apex ; Pterostigma very pale amber ; Hamuli of weak development, six in number.

Locality : Bungulla, West Australia, October 1st, 1929.

Allies : *H. raymenti* Ckll, which has a black patch on the abdomen, and is larger, and *H. erythrurus* Ckll, which has a striate sculpture on the metathorax ; neither of these is so iridescent.

I have dedicated the species to the collector, Mr. Tom Greaves, a fellow member of the Entomological Club.

Type in the collection of the author.

Halictus erythrurus maiusculus, new sub-species.

The Perth specimens are certainly larger than *H. erythrurus* Ckll., from Victoria and Queensland, but with the exception of stature, it is difficult to separate them. These western bees measure 5–6 mm. in length, whereas the eastern species measure 4 mm. approx. The flagellum beneath is somewhat paler, and the metathorax is more bronze, but the striate sculpture is similar. The anastomosing rugae of the blackish metathorax present no differences. The abdomen is of a like reddish-brown, the basal segment has a similar black patch, and the hind margins of the segments have the minute fringe of pale hair. The hind calcar has the one strong tooth and wave-like edge of *erythrurus*. The dark legs have similar long white hair. The nour-

ation of the wings and the pterostigma are darker ; the second and third intercubitus, and the second recurrent nervures, though weak, are much stronger than those of *H. erythrurus*, those portions being almost obsolete in the species.

Locality, Perth, West Australia. October 19th, 1929. (Tom Greaves).

Type in the collection of the author.

Paratype in the W.A. Museum.

Division **MEGACHILIFORMES**

Family MEGACHILIDAE.

Megachile maculatis, Dal. Tor.

A female was collected by Mr. T. Greaves, at Bungulla, October 1st, 1929, and this eastern species is now added to the fauna of the western State. The specimen is slightly longer than the Victorian and Queensland species, and there is less hair about the clypeus. My northern specimens were taken on *Daviesia ulicina*, and, under the microscope, I was unable to distinguish any difference in the pollen-grains carried by the two bees ; of course, there are plenty of *Daviesia* species in Western Australia, but I was pleased to prove the bee faithful to its food-plant.

Megachile heriadiformis, Smith.

One female conforms to Smith's description in size, namely, 5 lines, and also in sculpture, but differs slightly from the geno-type—described from Adelaide—in the colouring of the hair in the sixth abdominal segment, which Smith says, is "golden yellow." The specimen before me has only a few golden hairs, scattered among white ones. On the fourth, fifth and sixth segments there are, laterally, a few coarse black hairs. The abdominal scopa is loaded with pale-yellow pollen-granules, but the pilosity appears to be white. The hair of the abdominal dorsal segments is sufficient fo form narrow bands, instead of the "short fascia" laterally, of the type. However, the structure is similar, even to the two minute tubercles on the anterior margin of the clypeus.

Bungulla, West Australia, October, 1929. (Tom Greaves).

Previously recorded from Yallingup, West Australia.

Megachile trichomarginata, new species.

Female : Length, 14 mm. approx.

Head large, longer than wide, densely punctured, black, bright ; Face-marks, nil ; a tuft of silvery white hair at sides of face ; Frons densely and coarsely punctured, with coarse black hair ; Clypeus transverse, anterior edge concave and crenulate, polished, anteriorly a few coarse punctures ; Supraclypeal area polished, numerous punctures of irregular size ; Vertex densely punctured, roundly developed ; Compound Eyes with anterior margins parallel, claret brown ; Genae excessively and coarsely punctured, shining, a few long white hairs ; Labrum concave, a few large punctures, highly polished, black ; Mandibulae strong, broad, ruggedly sculptured, black, shining, a long fringe of golden-red hair on the posterior and cutting edge ; Antennae submoniliform, black.

Prothorax not visible from above ; Tubercles with a tuft of long white hair, black ; Mesothorax densely and coarsely punctured, shining, black, a few short white hairs ; Scutellum similar to mesothorax ; Postscutellum

similar to mesothorax, but with more hair ; Metathorax rugose basally, a fine scale-like sculpture beyond ; Abdominal dorsal segments ; densely punctured, one and two constricted, white hair-band on one, two with lateral patches, six with a ferruginous spot ; Abdominal ventral segments similar in colour and sculpture, a scopa of whitish hair.

Legs black, shining, densely punctured, with white hair ; Tarsi black, except the ferruginous fifth tarsus, yellowish hair ; Claws ferruginous ; Hind Calcariae finely serrated, black ; Tegulae with a concentric striate sculpture, densely punctured, bright, black ; Wings dusky, iridescent, anterior 9 mm. ; Nervures blackish brown, basal meeting nervulus, both recurrents entering second cubital at ends ; Cells : costal edge of radial broad and dark, second cubital contracted at apex ; Pterostigma narrow, blackish ; Hamuli eleven in number, well developed.

Perth, West Australia. October 19th, 1929. (Tom Greaves).

Allies : *M. trichognatha* Ckll., which is smaller, 10 mm., with a snout-like median apical elevation on clypeus, flagellum ferruginous beneath, dark fuscous or ferruginous nervures, dull area of metathorax, abdominal segments two to four constricted basally.

M. fulvomarginata Ckll., which has fewer punctures on cheeks, calcariae pale yellowish, a median process on clypeus.

I obtained a few Acarid mites from the hairs of the metathorax.

Type in the collection of the author.

Co-types in the collection of the Agricultural Department, Perth.

Division **XYLOCOPIFORMES.**

Family CERATINIDAE.

Exoneura punctata, new species.

Female : Length, 7 mm. approx.

Head wider than thorax, black, shining, a delicate sculpture, and scattered punctures ; Face-marks confined to a subobsolete reddish-amber T, a thin rod on some, or a spot ; Frons widely excavated at bases of antennae ; Clypeus prominent, with large coarse punctures, and the T mark described ; Supraclypeal area rising to a carina half way to median ocellus ; Vertex adapted to the mesothorax, a few coarse black hairs ; Compound Eyes with anterior margins parallel, as in *E. hamulata* ; Genae large, black, shining, scattered coarse punctures ; Labrum suboval, reddish-amber ; Mandibulae black with reddish tips ; Antennae submoniliform, black, with an obscure reddish line on scapes, segments of flagellum wider than long.

Prothorax not visible from above, scattered pale hair on mesopleura ; Tubercles black, with a fringe of dull white hair ; Mesothorax black, shining, a delicate sculpture, and scattered large punctures along anterior ; Scutellum similar to mesothorax in sculpture and colour ; Postscutellum similar to mesothorax but duller ; Metathorax black, bright, the scale-like sculpture well defined ; Abdomen with dorsal segments dark rich red, four and five with scattered coarse black hair, the apex with golden hair, one and two with a small median black mark, this is very variable ; Abdomen with ventral segments rich red, few pale hairs.

Legs dark rich red, coxae black, hair on tibiae golden, darker anteriorly Tarsi rich reddish-amber ; Claws rich red ; Hind Calcariae amber, with ex;

ceedingly fine serrations ; Tegulae black, with wide amber margin, shining ; Wings dull amber colour, anterior 5·5 mm. ; Nervures dark brown ; Cells normal for the genus ; Pterostigma large, dark brown ; Hamuli eight in number, weakly developed.

Locality, Albany, W.A. (Tom Greaves). 23rd October, 1929.

Allies : *E. baculifera* Ckll, which is smaller, and has black hair on hind tibiae ; *E. hamulata* Ckll, which has a large hooked T cream-colour ; *E. simillima* which is smaller, and has yellow tubercules ; *E. bicolor* Smith, which has a creamy inverted ⌊ on the clypeus.

Type in the collection of the author.

Paratypes in the Perth Museum.

Exoneura angophorae occidentalis Ckll.

A large series of females, collected at Kalamunda, showed great variation in size ; the majority agreeing with Prof. Cockerell's description 6½–7 mm. The smallest measured only 5 mm., and since each abdominal segment of this bee showed a broad bi-undulate dusky band (confined to the second segment in the sub-species) it might be regarded as variety A. The basal segment of the variety has the black mark of the sub-species ; the hind border of the black being obtusely bilobed. The tegulae of the variety has a pale margin—reddish in the sub-species. The black scapes have an obscure reddish line on the front, though Prof. Cockerell gives "yellowish red" as an alternative. Two mm. is a considerable difference in size, but that is not unusual among bees, for during development they are often affected by changes in the temperature of their surroundings, and the quality of their food. These bees are all reed-dwellers, and, therefore, are subjected to greater variations in temperature than, say, the *Paracolletes* in her chamber five or six feet deep in the earth. The bees of this genus are very fond of the plants *Callistemon* and *Bursaria*.

Kalamunda, Western Australia, November 2nd, 1929. (Tom Greaves).

Previously recorded from Yallingup, W.A.

Specimens sent to W.A. Museum and the Agricultural Department at Perth.

REFERENCES.

1. Fred. Smith, 1885, Catalogue of the Hymenoptera in the British Museum.
2. R. C. L. Perkins, 1912, Annals and Magazine of Natural History.
3. Prof. T. D. A. Cockerell, 1905, Annals and Magazine of Natural History.
4. Prof. T. D. A. Cockerell, 1910, Journal New York Entomological Society.

Note.—The Divisions are those of T. D. A. Cockerell, and W. W. Robbins. (University of Colorado Studies Vol. VII., No. 3, p. 179, 1910.)

The description of the neuration of the wings is based on the arbitrary method of Messrs. Rohwer and Gahan. ("Horismology of the Hymenopterous wing." Proc. Ent. Soc. Washington xviii., pp. 20–76, 1916.)

It will be noticed that I have systematised the specific descriptions, and this form will be used for all future work.

5.—"ZEBRA ROCK" FROM THE EAST KIMBERLEY.*

By

R. A. Hobson, B.Sc. (Hons.).

(*Read* 8th July, 1930; *Published* 25th July, 1930.)

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2.—INTRODUCTION.

Attention seems to have been first directed to this rock in 1924 when two specimens were collected by Mr. T. Blatchford, and described by Dr. Larcombe. The collection of specimens which are here described was obtained by Professor Clarke in 1926, and the appearance of typical specimens is illustrated in Figs. 17, 18 and 19.

3.—FIELD OCCURRENCE.

The specimens were obtained from about 3 miles S.W. of Argyle Downs Station, and the field relations of this rock were described by Professor Clarke in field notes as follows:—

"*Zebra Rock.*"—This occurs on a low ridge striking between 50° and 55° and traceable for about half a mile. At the northern end are large outcrops of red sandstone like that noted close to Mt. Misere, but here standing on edge, while half-a-mile or so to the east are large flags of Salterella limestone. One therefore has the choice of correlating the Zebra Hills vertical sandstone with the steeply dipping, but not vertical sandstone, of the hills near Mt. Misere or with the vertical quartzites and phyllites which are thought to be of late Pre-Cambrian age. On the whole it seems more likely that they are the equivalents of the dipping sandstone and therefore are at the base of the Salterella series and are of middle or lower Cambrian age. Followed to the south-west along the strike the sandstone is seen to be interbedded with red shaly mudstones which apparently thicken in this direction and the sandstone becomes more quartzitic and also shows a banded contorted structure. In the shale begin to appear white circular spots. As one moves farther south-west these spots become more numerous and coalesce. Most stages can be found between the spotted rock and the well known striped red and white rock. The only explanation that suggests itself to me is that some process of leaching began at certain centres possibly where crystals of pyrite occurred in the rock and these leached areas gradually extended. After leaching had proceeded to a certain stage it was superseded by infiltration with silica which led to the formation of the Zebra rock. At the south

* Part of work submitted for degree of B.Sc. (Hons.) in University of W.A.

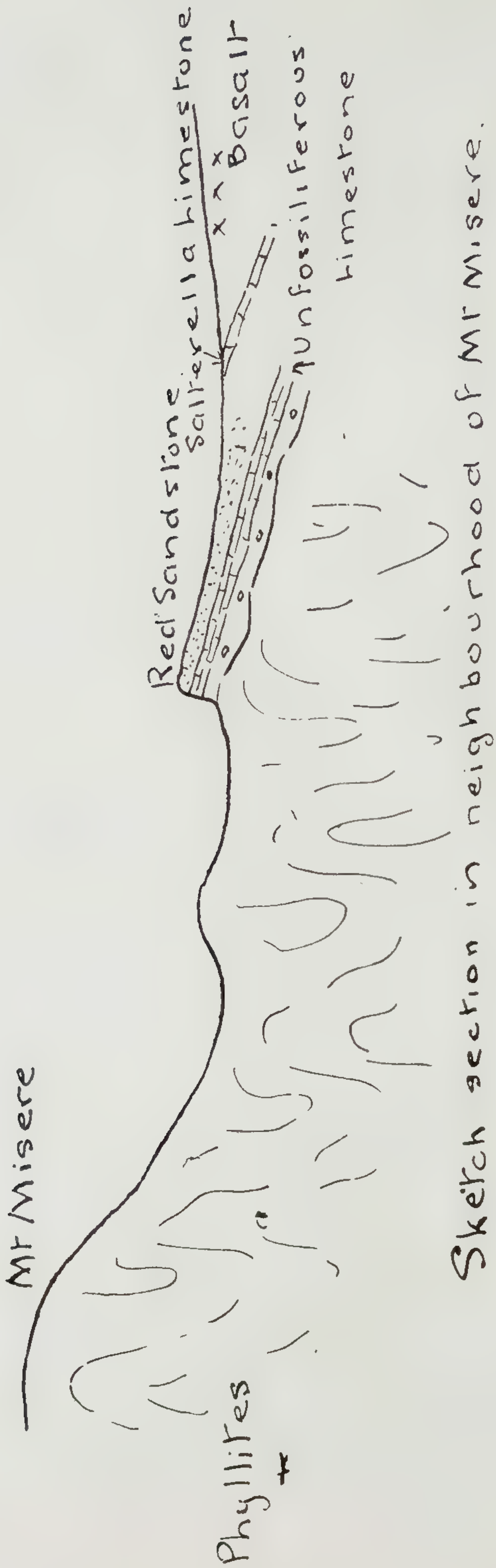
Mr Misere
Red Sandstone
Salterella Limestone
Basalt
Unfossiliferous Limestone
Phyllites
Sketch section in neighbourhood of Mr Misere.

Fig. 16.

end some of the *sandstone* also shows the zebra banding to a minor extent. Specimens of the unstriped mudstone and of a peculiar but rare greenish hard sandstone were also collected with the idea that they may represent the original rock."

4.—PREVIOUS DESCRIPTIONS.

Larcombe, C. O. G. (1924).—(i) Two rocks are described, one from the Ord River. The other from the Oakover River (in the N.W. Division) is evidently similar to the Zebra rock. He notes that "the ferruginous patches pass by insensible gradations into the surrounding clay rock." He concludes that the rock has been deposited in deep water far from land, that the coloured patches have been caused by "oxide of iron deposited from iron bearing solutions that have segregated along these specific areas" and that the two specimens are similar.

Larcombe, C. O. G. (1926).—(ii) Describes a banded rock from "4 miles east" (iii) of the Argyle Station. He notes that the rock consists of red and white bands, not sharply marked off from each other and that it is similar to rocks described above. For the origin of the rock he suggests deposition of alternate layers of ferruginous and non-ferruginous material, or, where the bands are not continuous, segregation of the iron oxides.

Blatchford, T. (1927).—(iv) With locality map and photograph of rock. He describes the field occurrence and appearance of the rock and agrees that it probably is due to leaching out of the iron oxide, but notes that there seems to be no reason why the coloured bands should be so regular. Specimens were obtained about three miles to the S.W. of the Argyle Homestead.

Through Dr. Simpson I have obtained the following analysis :—

Red and grey banded shales, Argyle Downs, East Kimberley (4 miles east of Homestead) (iii).

	Red Bands.	Grey Bands.
SiO_2	59·80	63·41
Al_2O_3	23·45	25·11
Fe_2O_3	5·73	1·12
FeO	·18	·02
MnO	*Nil*	*Nil*
MgO	·17	·11
CaO	·20	*Nil*
Na_2O	·08	·12
K_2O	·82	·82
H_2O —	·37	·35
H_2O + ...	8·45	8·82
TiO_2	·57	·44
CO_2	*Nil*	*Nil*
P_2O_5	·17	*Nil*
FeS_2	*Nil*	*Nil*
C	*Nil*	*Nil*
$B_2O_3ZrO_2$	trace	trace
	99·99	100·32
Sp. Gr.	2·61	2·61

Analyst: H. P. Rowledge, 1926.

(i) Larcombe, C. O. G., Ann. Pro. Rep. Geol. Survey, W.A., 1924, p. 19.
(ii) " " " " " 1926, p. 23.
(iii) Rocks described by Dr. Larcombe and analysed by Dr. Simpson are described as coming from four miles *east* of the Argyle Station. It is thought probable, however, that this should be four miles west of Argyle and that they were obtained from the same place as the rocks described in this report.
(iv) Blatchford, T., Ann. Pro. Rep. Geol. Survey, W.A., 1927, p. 14.

5.—DETAILED PETROLOGY.

Specimens examined in detail.—These were selected from numbers 7040–7053 of the general collection of the Geology Department of the University of W.A. Sections were cut from most of them and from some the heavy minerals were isolated. As the percentage of heavy minerals present was found to be very small it was necessary to take large samples for separation. From 400 to 1,000 gram samples were used and even then only small quantities of concentrate were obtained. The rock samples were crushed to pass through a 30-mesh sieve and the isolation of the heavy minerals was effected by panning and the use of bromoform, etc., in the usual way.

7040.

According to the field notes this is a typical specimen. The rock has in some places red cylinders or rods with a diameter of ½in. to 1in., and in other places red bands distributed through the white matrix. If the specimen is broken at right angles to the longer direction of the cylinders, then these are seen to be regularly arranged and to have a more or less oval cross-section. This is shown in Fig. 17. The red spots are arranged

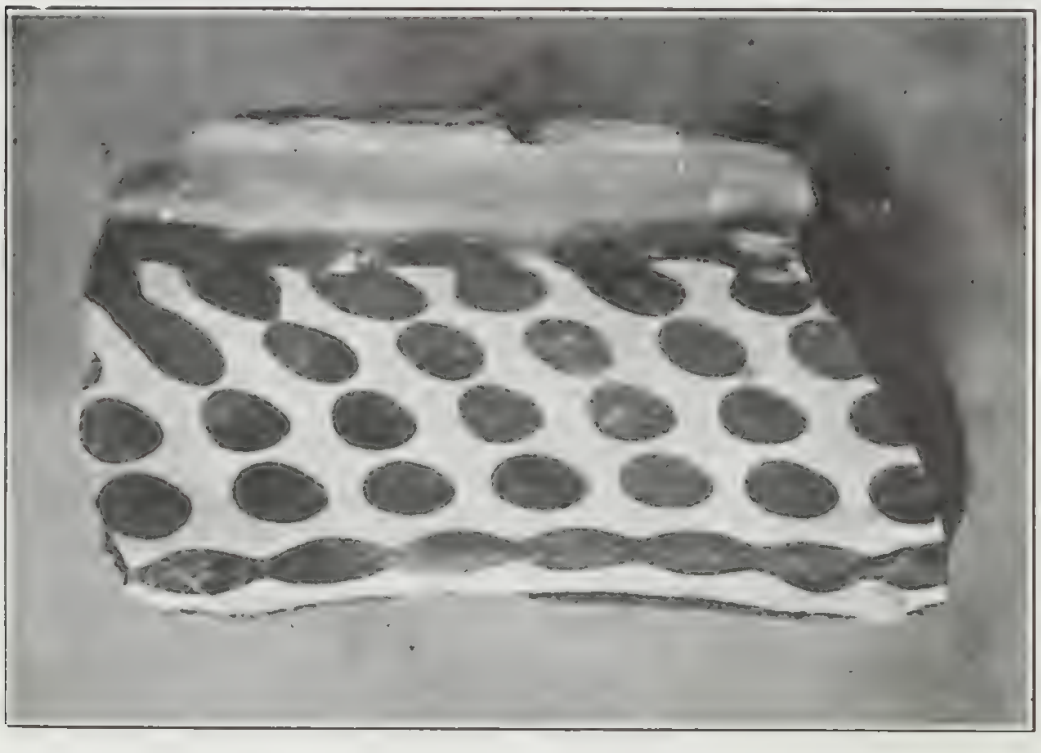

Photo.: H. Smith. Spec. 7040 x 9/20.

Fig. 17.—Zebra rock from the Kimberley Division, showing the oval shape of the rods when broken at right angles to their longer direction and their regular arrangement. Also the transition between the bands and the rods.

parallel to the base and also to the right hand edge of the specimens. The two top rows show a gradual transition from the red bands to separate red "spots." From the left to the right the separation of the "spots" becomes more complete and indicates a transition from one to the other. At the bottom of the specimen there also seems to be a transition from a band to a row of "spots" (*or* more accurately rods). When the rock was broken

parallel to the longer direction of the rods it was found that the rods, although continuous for some distance ended at a certain point and other rods commenced not far away (Fig. 18), the important point being that the rods

Photo.: H. Smith. Spec. 7040 x 1/3.

Fig. 18.—Zebra rock broken parallel to longer direction of the rods.

Photo.: H. Smith. Spec. 7040 x 1/3.

Fig. 19.—Zebra rock showing parallel bands and the transition from these to rods.

are not indefinitely continuous. Some specimens show a different arrangement (Fig. 19). In this there are parallel bands showing a gradation into spots. From the right to the left of the specimen the spots become more and more separate from the bands. Notice that the arrangement of the bands is similar to that of the "spots" previously shown in Fig. 17. This would suggest that the bands may have formed first and that the spots have gradually separated from the bands.

Under the microscope the rock is seen to consist of minute grains of quartz with an aluminous cement. The red portions are opaque unless the section is very thin. In thin places the red portions of the rock appear similar to the white portions with the addition of ferric oxide and the boundary between the two is sharp. With crossed nicols the similarity of the two portions is more evident.

For the determination of the heavy minerals of the red and the white portions the rock was broken up into small fragments and the red and the white portions of the rock were separated. The heavy minerals of each were determined with the object of finding differences or resemblances. If the two portions had been deposited at different times then each might have a different suite of heavy minerals. The percentage of heavy minerals in each is :—

7040—white portion .... ·015 per cent.

red portion .... ·002 ,,

The heavy minerals of the white portion of 7040 are Magnetite, Ilmenite, Leucoxene, Hornblende and Andalusite (?). The first three minerals are most abundant and leucoxene grains may be white or brown. Hornblende occurs as green grains with ragged edges with pleochroism from light green to dark green. Only a few grains of andalusite (?) occur. The heavy minerals of the red portion of 7040 are larger in size than those of the white portion and also less abundant. Magnetite and ilmenite grains are scarcer and leucoxene grains are often of the brown variety. Hornblende grains are larger and more abundant than in the white portion. Tourmaline fragments occur showing very strong pleochroism and also single fragments of Titanite, Spinel (?), Corundum (?), and Zircon (?) were observed. Owing to the small quantity of the concentrate obtained, the identity of these mineral fragments must remain doubtful. Thus there are differences between the heavy minerals of the two portions.

7042.

"*Red and white banded argillite, less perfectly banded with a predominance of red.*" The rock is mainly red-coloured, but contains white bands irregularly distributed. On one face the specimen shows an arrangement of red and white bands, similar to but less regular than that illustrated in Fig. 19. The boundaries of the lighter coloured bands are in some portions of the rock very indefinite and the colour is a light brown. These may be ntermediate between the white and the red portions of the rock.

Under the microscope the rock is seen to be similar to the red portions of 7040.

The percentage of heavy minerals was found to be ·012 and it should be noted that this is nearer to the percentage in the white portion (·015%

)

of 7040 than to the percentage in the red portion (·002 %). Magnetite, Ilmenite and Leucoxene make up the main portion of the concentrate. Hornblende, similar to that found before, and also one doubtful fragment of titanite, are present. Thus the heavy minerals of this concentrate (7042—red) resemble those of white portions of 7040.

7044.

"*Red argillite with suspicion of white bands of the broader type.*" The surface of this specimen shows small circular white areas represented by small holes on the weathered surface. These are found both in the white and in the red portions.

Specimen number 7044 was found to contain ·009 % heavy minerals. Magnetite, Ilmenite and Leucoxene were abundant. Andalusite (?) was also present.

7046.

"*Spotted red and white argillite—red being predominant—possibly by the coalescence of these white spots in such a rock as this the fine banded red and white argillite would be formed.*" The specimen shows white spots of irregular shape and size irregularly distributed in a red matrix. The average size of the white spots would be about $\frac{1}{4}$in. in diameter. Specimen 7048 consists of alternate dark and light reddish bands with white spots similar to those in 7046 in the lighter-coloured bands. The banding in 7048 is quite regular, but the specimen is small.

In section the rock (7046) was found to consist of quartz grains, there being no difference in shape, size, etc., between the grains in the red and those in the white portions. The boundary between the red and white portions is sharp.

7049.

"*Banded argillite, ripple-marked. Banding is clear, but not so sharp as in* 7040 *or* 7041. *Appears to be parallel to the bedding planes, and there are numerous pinholes due to leaching.*"

In section the rock appears to be similar to previous rocks. It is slightly coarser-grained and contains areas from which quartz grains are absent, and in which the cementing material is concentrated. A few wisps of mica are present.

The ripple marks referred to in catalogue description form a series of more or less parallel ridges and troughs with a wave length of less than $\frac{1}{2}$in.

7050.

"*Red argillite associated with* 7040. *It is current bedded or slightly squeezed and shows some banding parallel to stratification. Also shows pinholes.*"

The specimens catalogued under 7050 showed considerable variation in grain size, from typical fine-grained specimens to coarse sandstone. The specimens examined were :—

7050A—Specimen showing current bedding (?)

7050B—Coarse-grained specimen.

7050C—Specimen showing inclusion (?) of coarse-grained rock in fine-grained rock.

7050A.

Under the microscope the rock was found to consist of quartz grains of an irregular shape but all about the same size. Grains are larger than those in previous rocks. Banding seen in the hand specimen is due to grains of iron oxide arranged in parallel bands. With the exception of the presence of the ferric oxide these bands are quite similar to the rest of the rock. Wisps of mica and a few small grains of tourmaline are also present.

7050B.

In the hand specimen it is seen to be a sandstone with a ferruginous cement and showing bedding planes. In general appearance the rock is light coloured or red, due to iron oxide, but there are also dark-brown patches distributed irregularly throughout the rock.

Under the microscope the rock was found to be a typical sandstone consisting of quartz grains of an irregular size and shape with a cement of silica and iron oxides. Some of the grains show secondary silica grown in optical continuity around previously rounded quartz grains (Fig. 20). The iron oxide in the cement is concentrated into layers. Small fragments of white mica are present.

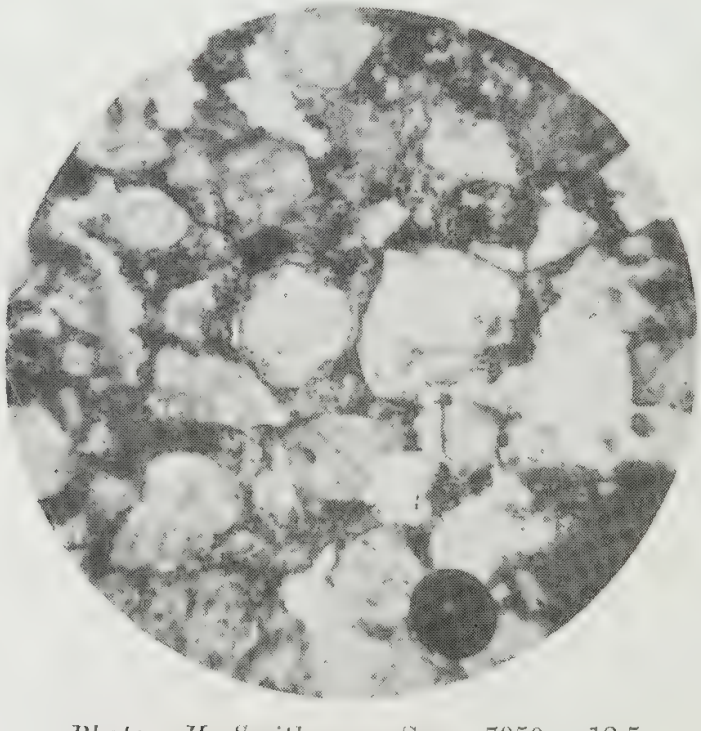

Photo.: H. Smith. Spec. 7050 x 12.5.

Fig. 20.

Showing the general appearance of the sandstone and the growth of secondary silica around rounded quartz grains.

This rock was found to contain ·011 % heavy minerals, consisting of Tourmaline, Zircon, Magnetite, Ilmenite and Leucoxene. Zircon is the most abundant mineral in this concentrate, and the grains vary considerably in form from perfect crystals to irregular fragments. Tourmaline grains are fairly abundant but vary in form and in pleochroism. Thus there is a difference between the heavy mineral suite of this sandstone and that of the rocks previously described, but it must be remembered that there is also considerable difference in grain size.

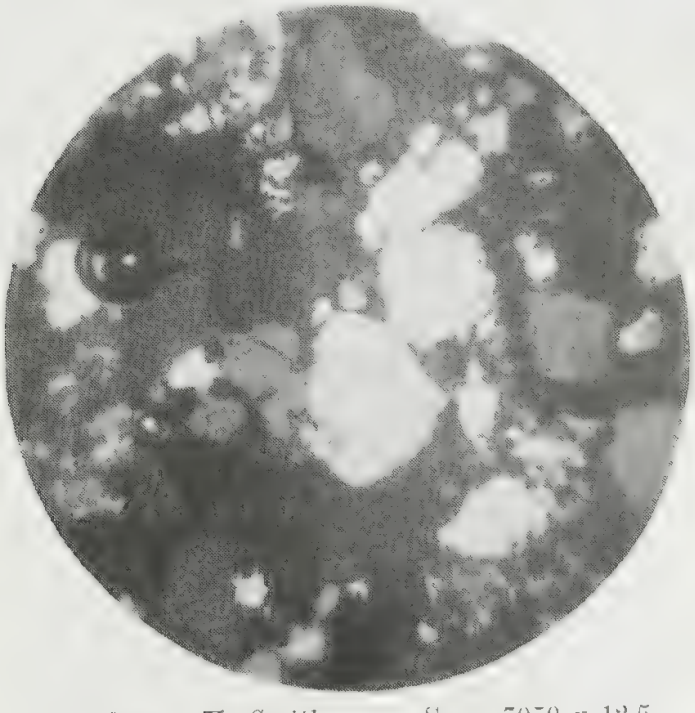

Photo.: H. Smith. Spec. 7050 x 12.5.

Fig. 21.

The same under crossed nicols showing optical continuity of the secondary silica.

Fig. 22.—Showing coarse-grained sandstone surrounded by fine-grained material.

7050C.

The peculiar feature of this specimen is the apparent inclusion of a pebble of coarse-grained sandstone in finer grained material. The appearance of the specimen is shown in photographs 23 and 24.

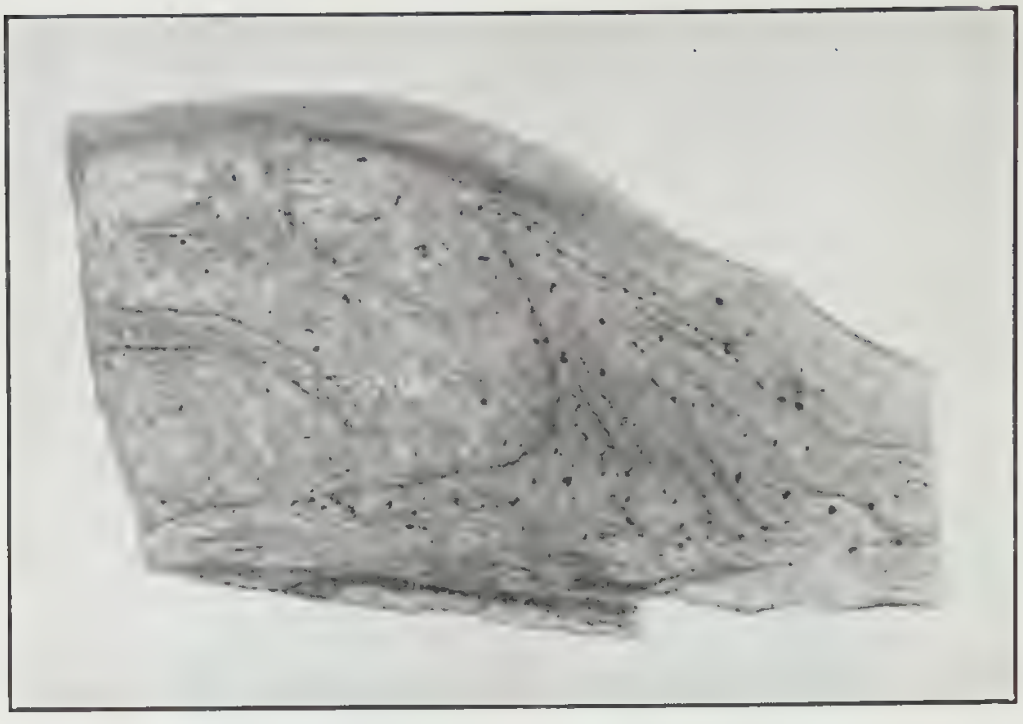

Photo.: H. Smith. 7050 x 10/9.

Fig. 23.—Showing the appearance of the specimen on the weathered surface.

The unweathered surface shows the bedding planes of the fine-grained material wrapped around the coarse-grained fragment. A polished surface —parallel to the previous one, but on the opposite side of the specimen— showed a different arrangement of coarse and fine-grained material.

Photo.: H. Smith. 7050 x 10/9.

Fig. 24.—Showing a polished surface of the specimen.

Whether or not the coarse-grained material is part of a relatively small inclusion in the finer-grained material cannot be decided from the specimen. From the arrangement shown in the photographs it would be conceivable that the fine-grained material had been deposited around the coarse-grained fragment, but the arrangement of coarse and fine material in the above sketch would not be likely to result from this process. Professor Clarke has suggested that this specimen may represent a sandy bed which has slumped into an unconsolidated bed of finer-grained material. The boundary between the coarse and fine parts is quite sharp.

Under the microscope (Fig. 25) the rock was found to be made up of quartz grains with a cement of silica and iron-oxides. The coarser material resembles number 7050B, while the finer material is similar to the previously described fine-grained rocks, but it must be remembered that there is also considerable difference in grain size.

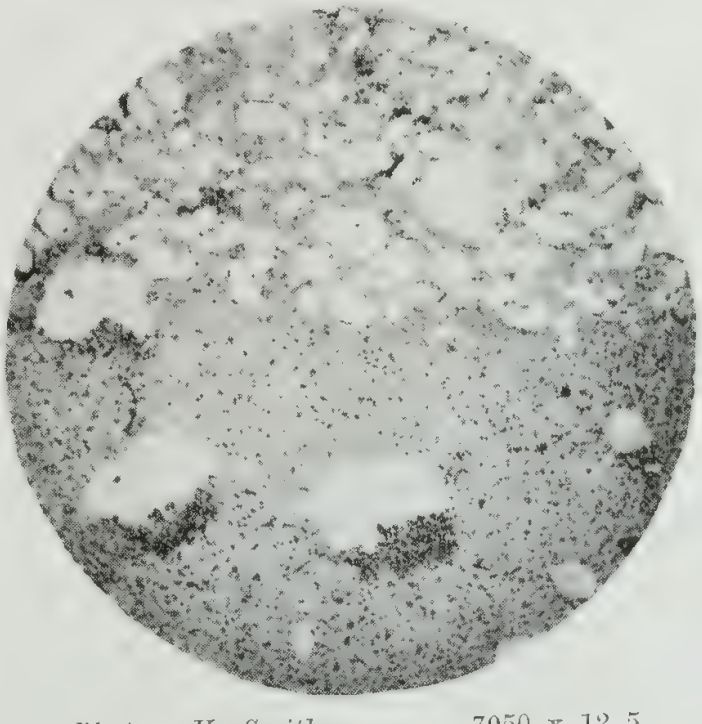

Photo.: H. Smith. 7050 x 12.5.

Fig. 25.—Showing coarse and fine-grained portions of 7050C and the sharp boundary between the two. (The large white patches in the lower portion of the picture are holes in the section.)

7051.

"*Red argillite shows no banding or spotting. It is perhaps the original rock from which the Zebra rock developed by leaching, etc.*"

This was examined for heavy minerals with the idea of comparing these with the heavy minerals of the typical zebra rock. The percentage of heavy minerals was found to be ·001 per cent. (*c.f.* red portion of typical rock) and consisted of magnetite, ilmenite, leucoxene with hornblende, together with single fragments of zircon, pyrite (?) and andalusite (?). The small quantity of the concentrate obtained renders accurate determination of the less abundant fragments impossible. Apart from the quantity these minerals are very similar to those obtained from other rocks.

7053.

"*Greywacke* (?) *associated with the red and white argillite belt.*"

In the hand specimen the rock is a chocolate colour showing fragments of felspar with crystal faces. Also a green mineral can be seen. Rock is evidently very weathered.

Under the microscope the rock is seen to be altered, but is certainly an igneous rock. Two generations of felspar occur. Phenocrysts are not abundant and are very altered. The extinction angle varied between 0° and 28°, and in one place traces of lamellar twinning were seen. Felspars of the groundmass are hypidiomorphic and show lamellar twinning. There is present a colourless mineral with high polarisation colours and having a higher relief than the associated felspar. It is often twinned and is bi-axial. In one place two cleavages at 90° were seen and the same crystal was bi-axial and positive. Extinction angle is large. The mineral is colourless augite. Green chloritic material and iron-oxides are also present. Rock is therefore a basalt.

Specimens not examined in detail.

Other specimens which are included in the field collection made by Professor Clarke, but which have not been examined in detail in the laboratory, are :

7041.

"*More finely banded than* 7040."

Also banding is less regular. This is illustrated in Fig. 26.

Photo.: H. Smith. Spec. 7041 x 9/20.

Fig. 26.

Finely banded zebra rock.

7043.

"*Red and white banded argillite—finer banded type. Banding less perfect than* 7041. *Red colour predominant.*"

7045.

"*Red argillite with shadows of white bands due to more or less regularly aligned whitish spots—(?) due to leaching.*"

This rock is coarser-grained than typical zebra rock and approaches to the sandstone of 7050. In this rock there is a predominance of the dark brown colour noted in 7050.

7047.

"*White and red argillite. An exceptional type, in which the white predominates.*" (Small specimen.)

7048.

"*Red and white banded argillite, but the light bands are still reddish except where white spots occur.*"

Note that the white spots are restricted to the lighter coloured bands. (Small specimen.)

7052.

"*Red argillite but shows portions of a lighter colour.*"

There is a gradual transition from red rock to lighter coloured rock.

6.—SUMMARY AND CONCLUSIONS.

The typical Zebra rock from the East Kimberley consists of very small quartz grains with an aluminous cement. In parts of the rock iron oxide is present, causing the strange appearance of the rock. Sections show that the boundary between the red and the white portions is sharp, but that the general appearance of each (except, of course, that due to iron oxide) is similar.

——	Heavy Minerals.	Magnetite.	Ilmenite.	Leucoxene.	Tourmaline.	Titanite.	Spinel.	Corundum.	Zircon.	Andalusite.	Hornblende.
7040 (white) ...	·015%	×	×	×	...	...	...	...	...	×	×
7040 (red) ...	·002%	×—	×—	×	×	1	?	?	?	...	×+
7042 (red) ...	·012%	×	×	×	...	...	...	...	...	...	×
7044	·009%	×	×	×	?	...	...	...	...	×	...
7051	·001%	×+	×	×	...	...	...	...	?	?	×
7050B	·011%	×—	×—	×	×+	...	...	...	×+	...	...

The above table gives the heavy minerals of the rocks examined and indicates that there are differences between the red and white portions of the typical rock, both in total quantity of the minerals present and also in the quantities of tourmaline and hornblende. In view of the small amount of the concentrates obtained and the similarity in quantity of heavy minerals of the red portion of 7042 to the white portion of 7040, I feel that little stress

can be laid on these differences. Further, the chemical analysis of each is very similar (i), the most significant difference being the increase (4·61%) of iron oxide in the red portions. This demonstrates the small quantities of iron oxide required to colour a rock strongly. I think that the two portions of the rock must be regarded as very similar. Associated rocks vary in grain size from fine-grained rocks to coarse sandstones. Banding somewhat similar to that of the typical rock is found in other specimens, but bands may be a different width or may be less strongly defined or both. Many of the rocks are mainly red with only a few white portions, and in some white circular spots with a definite boundary are found (ii).

Origin of the Zebra Rock.

It seems impossible to imagine that the typical zebra rock, and also many of the associated rocks, have originated in the way suggested by Dr. Larcombe for the banded rock examined by him, *i.e.*, by alternate deposition of ferruginous and of non-ferruginous materials. Judging from the higher heavy mineral content of the white portion of 7040, it does not appear that that part was originally red and has been leached as suggested by Professor Clarke. Moreover, only one doubtful pyrite grain has been obtained. Nothing has been observed which suggests a cause for the very regular arrangement seen in the typical specimens.

(i) Chemical analysis is that given in the earlier part of the report. It should be noted that the rocks actually examined were not analysed.

(ii) Owing to Mr. Hobson's absence from Perth, it has been impossible to submit to him the proofs of this paper. The symbols used in the table on the preceding page appear from the context and from Mr. Hobson's laboratory notes to have the following significance :—

× present, ×+ abundant, ×— rare, 1 single grain observed, ? doubtful.

[Editor, Journ. Roy. Soc., W.A.]

6—CONSTITUTION OF A COPPER TELLURIDE FROM THE KALGURLI G.M., KALGOORLIE.

By

D. G. Murray, A.A.C.I.

(*Read 10th June*, 1930; *Published 28th July*, 1930.)

The material, which was received for examination from Dr. F. L. Stillwell, of the Council for Scientific and Industrial Research, was in the form of a fine black powder. The locality given was the No. 4 level, Kalgurli Mine, a short distance below the oxidised zone. Mr. Paton, Metallurgist of the South Kalgurli Mine, who, I understand, first collected the specimen, does not think that it has been found in any other mine in the district, and only over a very limited area there.

The composition of the powder is shown in the following analysis:—

	%
Gold	23.16
Silver	2.77
Copper	32.22
Tellurium	42.06
Iron	0.13
Lead	trace
	100.34

The object of the investigation was to discover, if possible, the relationship between the elements present and whether the percentage composition corresponded to a simple molecular ratio or to a mixture of elements and chemical compounds. To this end experimental work was conducted which led to the discovery that almost all the copper and tellurium present in the sample could be dissolved out with a solution of ammonia, the other constituents remaining unattacked.

Based on this fact the following method of analysis was adopted:—

A weighed portion of the powder was placed in a small silica beaker and treated with warm 5 E ammonia. The solution was decanted off at intervals and repeated applications of fresh solvent made until no further solution of copper took place. The residue, consisting mainly of gold, was caught in a tared sintered glass filter crucible, washed, dried at 105° C., and weighed. Copper and tellurium were determined in the ammoniacal filtrate.

The residue, insoluble in ammonia, was leached with a weak (0.2%) solution of potassium cyanide until the free gold was removed, and weight of crucible and residue after drying at 105° C. remained constant.

The residue, insoluble in potassium cyanide, was treated on the crucible with warm 10 E nitric acid until no further action took place. This decomposed any remaining telluride mineral unattacked by the previous treatment.

Copper and tellurium were determined in the nitric acid solution.

The final residue in crucible, returned as insoluble in nitric acid, was gold apparently resulting from the decomposition of a telluride of gold and copper.

The figures obtained by this method of treatment are shown hereunder:—

		%	Mols.
Soluble in 5 E ammonia—			
	Copper	31.80	500
	Tellurium	39.26	308
Soluble in 10.2% potassium cyanide—			
	Gold	22.26	113
	Silver	2.77	26
	Copper	0.02	
Soluble in 10 E nitric acid—			
	Copper	0.40	6
	Tellurium	2.80	22
	Iron	0.13	2
Insoluble in 10 E nitric acid—			
	Gold	0.90	5
		100.34	

These results give the ratio of copper to tellurium in the ammonia soluble portion as very nearly 5 to 3. By applying the method generally used in the calculation of mineral formulae the composition of the powder would appear to be as follows:—

	%
Cu_5Te_3, soluble in ammonia	71.06
Au, Ag, Cu, soluble in potassium cyanide ..	25.05
(Au, Cu) Te_2 decomposed by nitric acid ..	4.10
Fe	.13
	100.34

It is suggested, therefore, that the powder consists of a mixture of telluride of copper, native gold, and telluride of gold and copper. Dr. Stillwell, who kindly read the first draft of this paper, suggests that Sylvanite is an important constituent of the mixture and should be found in the residue after treatment with ammonia and cyanide. Further, that the

residual copper is present as occluded granules of weissite. The analytical data, however, are not easily interpreted in this way, unless we assume that sylvanite is partly attacked by KCN with solution of gold and silver and separation of elemental tellurium. The formula found for the copper telluride Cu_5Te_3 agrees with that of a new mineral Weissite,* described by Mr. Wm. P. Crawford. This mineral occurs in the Good Hope and Mammoth Chimney Mine at Vulcan, Gunnison County, Colorado.

Rickardite, a telluride of copper, the formula of which is given as Cu_4Te_3, has also previously been recorded from the Good Hope Mine.

Analyses of the original American Weissite gave—

	1.	2.
	%	%
Copper	45.72	45.97
Tellurium	54.05	53.89

The ratio Cu : Te is very nearly 5 : 3.

It is not made quite clear in the paper referred to whether these analyses were made on separate samples or were simply duplicate determinations on the one specimen. If separate samples were taken the close agreement of the figures obtained would certainly indicate the existence of one definite compound, Cu_5Te_3, and not of a mixture of copper tellurides of varying composition.

It may be of interest here to study the composition of the following artificially prepared selenides and tellurides of copper and of the known minerals of these species.

Selenides of Copper†—

Artificial	Cu_2Se	Cu_3Se_2	CuSe
Mineral	Berzelianite	Umangite	Not known.

Tellurides of Copper—

Artificial ..	Cu_2Te	...	...	CuTe
Mineral ..	Not known	Weissite (Cu_5Te_3)	Rickardite (Cu_4Te_3)	Not known.

It will be noted that the two compounds known as minerals in the telluride group, Weissite and Rickardite, have not as yet been prepared artificially.

The possible occurrence, then, of a mixture of the two known artificial tellurides, Cu_2Te and CuTe, must be taken into account in the interpretation of any analytical figures obtained. Although the presence of the mineral Cu_5Te_3 is indicated in the material received from Dr. Stillwell this could not be definitely established as no metallographic data could be obtained owing to the nature of the sample submitted, a very fine powder. There still remains the possibility of a mixture of copper tellurides being present.

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* American Journal of Science, Vol. xiii., April, 1927.

† Doelter, Vol. iv., Part I.

A specimen of copper telluride was obtained from the Kalgurli Mine in 1921 by Dr. E. S. Simpson, Government Mineralogist and Analyst, W.A. The specimen is of a bronze colour, slightly tarnished, and shows gold freely in coarse masses and in finely disseminated flakes and grains. Gold can also be microscopically seen filling minute fissures in the surface of the mineral. The unbroken specimen shows no definite crystalline form, but bright individual cleavage faces with distinct outlines can be seen on the fracture surfaces.

Although no analysis has been made of the specimen, a qualitative examination showed the presence of abundant copper and tellurium, and it would appear to be of similar composition to Dr. Stillwell's sample, of which the analysis was made.

7.—THE REACTION OF WESTERN AUSTRALIAN SOILS.

L. J. H. Teakle and L. W. Samuel.

Introductory.

The importance of soil reaction has received emphasis in Australia, particularly in recent years, as a result of the publications and influence of Prescott (1927, 1928) and associates at the Waite Agricultural Research Institute in South Australia. It has been made clear that not only is the knowledge of soil reaction important from the point of view of crop growth, crop selection and manuring, but also as a criterion in soil classification and soil physiology. The effect of climate on rock weathering and soil formation is reflected by the hydrogen ion concentration of the soil suspension, and when regarded from the continental point of view the zonal distribution of soil types shows a very close correlation with climate. Of course many disturbing factors intervene to confuse, but it is always possible to recognise the *normal* soil types of any locality in spite of unconformities.

Prescott (1927) has shown for South Australia the effect of rainfall; other factors being equal, it is generally observed that soils of wetter districts are more acid than soils of dry districts.

The Scope of the Enquiry and Methods adopted.

The soils considered in this paper are all from the Southern part of the State, embracing practically all agricultural areas. The geographic positions of the localities from which samples have been obtained may be seen by reference to the map (Fig. 1). Practically all samples were collected by the senior author to represent typical soil conditions in the several districts, but only certain ones, which will receive special treatment, were sampled on a strict profile basis. In these cases pits were dug and the samples obtained from the walls somewhat similarly to the method of Polynov. The other samples were obtained mainly by the use of a soil auger, and the finer distinctions of the soil horizons not recognised. Nevertheless it is felt that these samples truly represent soil conditions, and the results of their examination are well worth publication in conjunction with the results from the analyses of the type samples more carefully selected.

In presenting the various ideas for consideration and criticism, it is necessary to acknowledge the helpfulness of discussions with Professor J. A. Prescott, of the University of Adelaide, during his extended tour of the country from which the samples were collected. Many of the ideas expressed in this paper have emanated directly from Professor Prescott, and the discussions during the progress of the trip have led to a considerable clarification of the problems of soil classification in Western Australia. Much remains to be done, but it is hoped that these preliminary results will be of assistance to colleagues, particularly in Australia, by affording data concerning the nature and distribution of our major soil types.

The reaction of the soils is expressed in terms of the pH scale. The determinations were made by means of the quinhydrone electrode, following the method of Bijlmann as outlined by Prescott and Piper (1928).

Results.

The soils of the Southern portion of Western Australia present a very confusing picture to the newcomer who attempts to classify the soils according to the zonal system. This is due to the effects of the geological history of this part of the continent resulting in a patchwork and admixture of ancient laterites and the more recently weathered material from basal rocks. The soils now being formed from the laterites, in themselves the remains of previous soils, do not conform to the soil types predicted from a consideration of the present climatic conditions; adjacent soils, whether formed from granites, basic dykes, or sedimentary rocks, may be regarded as "normal," and may be compared with soils formed under similar climatic conditions in other parts of Australia and of the world. Typical podsols are recognised at Albany and along the wetter portions of the coastline: the brown earths range from Cranbrook to Northampton and extend as far East as Bruce Rock and Corrigin. The mallee types, comparable with the mallee types of the Eastern States, extend from the brown earths eastward and northward. There appears to be a considerable overlapping of the brown earth and the mallee types.

Under these circumstances it cannot be expected that the various soil types of Western Australia will all conform to the climatic zones. It will be found, however, if the obvious anomalies are eliminated, if the laterites are treated separately and due allowance is made for admixture, the zonal system of soil classification may well be applied. In the consideration of the results of the soil analyses reported in this paper, an attempt will be made to separate the "normal" soils from the laterites. The separation is extremely difficult in many cases owing to the merging of the two types and to the anomalies resulting from probable admixtures of igneous and lateritic materials.

The records are presented statistically in the form of distribution tables according to the method adopted by Prescott (1927). In designing the tables an effort has been made to bring out the correlation between soil types, rainfall, and soil reaction, when "normal" soils are considered, Table 1, and the lack of correlation when soils of lateritic origin are studied, Table 2.

TABLE I.—DISTRIBUTION TABLE SHOWING RELATIONSHIP BETWEEN SOIL TYPE, SOIL REACTION AND PRESENT CLIMATIC CONDITIONS WHEN "NORMAL" SOILS ARE CONSIDERED.

Soil Type.	Locality.	Depth.	Rainfall.	Below 3·6	3·6	3·8	4·0	4·2	4·4	4·6	4·8	5·0	5·2	5·4	5·6	5·8	6·0	6·2	6·4	6·6	6·8	7·0	7·2	7·4	7·6	7·8	8·0	8·2	8·4	8·6	8·8	9·0	9·2
?	Ghooli ...	Surface 0–12in.	Inches. 9·44 (2 yrs.)	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	1	...								
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...								
Mallee	3,500 Farms Scheme	Surface	10–13*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	2	...	2	3	1	.	.				
		Subsoil	...		...	...	1	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	2	3	6	15	7	1			
Mallee	Lake Brown	Surface	10·37	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	..	...	1	1	1				
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					4			
Mallee	Lake King–L. Carmody	Surface	11·94*	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	.		1	6	1	6	5	3	
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...								
Mallee	Salmon Gums	Surface	12·75	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	2	1	...	2	1	8	3	1			
		Subsoil	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	1	...	...	...	1	3						
Mallee	Merredin ...	1st. ft., 2nd and 3rd ft.	13·18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	2	8	10	17		
			...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	9	21	6	
Mallee	Indarra ...	Surface	13·29†	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	2	2	2	1	3	2	2	2	2	...	...	
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	1	1	1	2	1	3	5	4	7	3	3	3	4	2
Mallee	E. Karlgarin	Surface	13·43	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	1	1	3	...	1	...	3	1	...	1	...
		Subsoil	(5 yrs.) ...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	1	2	3	4	...	...	1
Mallee	Ajana - Dartmoor	Surface	13·90	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	1	1	2	1	...	...	
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	2	...	4	1	1	...	
Mallee	Mendel ...	Surface	13·99	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	...	...				
		Subsoil	(1 yr.) ..		...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	3	...	...	2			
Mallee	Kondinin ...	Surface	14·00	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	.	1					
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	..	1		2	1	3		1
Brown earth ...	Quairading ...	Surface	15·03	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1				
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...		1			
Brown earth and mallee	Corrigin ...	Surface	15·75	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	2	...		1	1		1		
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...							
?	Three Springs	Surface	16·01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	...	...	...					1		
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...							
Basic rock weathering	Ravensthorpe	Surface	16·18	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...			1				
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...							
Brown earth, etc....	Pingelly ...	Surface	17·36	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	1	...	...	1	...	...	...						
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	1	...	1	1	...	...	...	...	...						
?	York ...	Surface	17·60	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1		1		
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...					
Brown earth ...	Northampton	Surface	18·21	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	1	...	1	2	...	...	...					
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	1	1	1	3		...	...					
Leached alkali ...	Moora ...	0–4in.	18·44	...	...	...	..	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	
		4–8in.	...	...	...	...	..	...	...	...	..	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Recent alluvium ...	Greenough ...	Surface	19·61	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	1	3	4	3	...	...	...	...	
		Subsoil	...	...	...	...	..	...	...	...	...	...	...	...	...	...	1	..	...	...	...	...	...	..								
Rendzina (1) Sands or grits	Gingin ...	Rendzina Sands or grits	31·08	...	...	...	...	...	...	...	...	...	...	1	1	...	1	...	...	1	...	...	1	1	...	...	...	...	...	...	...	...	
			...	...	...	...	...	...	...	...	...	...	...																				
Alluvial probably...	Busselton ...	Surface	32·04	...	...	...	...	...	...	...	...	...	...	...	...	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	2	2	2	...	...	2	...	...	...	...	...	...	...	...	...	...
Coastal limestone	Spearwood ...	Surface	36·21	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	2	...	1	...	...	...	...	...	...	...	...
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Coastal sands ...	Ludlow ...	Surface	...	...	...	...	...	...	...	...	...	...	...	1	1	1	3	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Coastal marsh ...	Capel ...	Surface	40·30	...	...	...	...	...	1	2	1	1	1	...	2	1	2	...	3	1	...	...	...	...	1	...	...	...	...	...	...	...	...
		Subsoil	...	2	...	2	1	2	1	...	2	...	2	1	1	4	...	3	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...
Tobacco	Manjimup ...	Surface	43·46	...	...	...	...	...	...	...	...	...	...	1	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...
		Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	1	1	1	...	...	...	...	...	...	...	...	...	...	...	...
?	Burekup (Roelands)	0 6in.	45·64	...	...	...	...	...	...	...	2	...	4	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		6–12in.	...	...	...	...	...	...	...	...	...	...	1	1	1	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Podsol	Nornalup ...	0–15in.	54·11	...	...	...	...	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
		15–36in.	...	...	...	...	...	...	...	...	...	1	...	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

* Records from stations along the No. 1 Rabbit-proof Fence. As these stations were visited but monthly these figures are undoubtedly low.
† Rainfall for Mullewa, 13 miles eastward.

TABLE 2.—DISTRIBUTION TABLE SHOWING LACK OF RELATIONSHIP BETWEEN REACTION OF LATERITIC OR LIGHT LAND SOILS AND PRESENT CLIMATIC CONDITIONS.

pH Value.

Locality.	Depth.	Rainfall.	Below 3·6.	3·6	3·8	4·0	4·2	4·4	4·6	4·8	5·0	5·2	5·4	5·6	5·8	6·0	6·2	6·4	6·6	6·8	7·0	7·2	7·4	7·6	7·8	8·0	8·2	8·4	8·6	8·8	9·0	9·2
Lake Brown ...	Surface	Inches. 10·37	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Subsoil	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	**1**	...	...	...	...	...	...	...	...	...	...	...	...
3,500 Farms Scheme	Surface	10-13*	...	...	...	...	...	1	...	...	1	1	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Subsoil	...	...	...	...	...	...	**1**	**1**	**2**	...	**1**	**1**	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Ajana - Dartmoor	Surface	13·90	...	...	...	...	...	1	...	...	...	1	...	1	1	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Subsoil	...	...	...	...	...	...	...	...	**1**	...	...	...	...	**1**	...	**1**	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Mendel ...	Surface	13·99	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...
	Subsoil	(1 yr.)	...	..	...	...	...	...	...	...	...	...	...	...	...	...	...	...	**1**	...	...	...	...	...	...	...	...	...	...	...	...	...
Wongan Hills...	Surface	15·36	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Pingelly ...	Surface	17·36	...	...	...	...	...	1	...	...	...	...	...	1	1	1	...	...	...	..	..	..	..	..	..	..	..	..	..	..	..	..	..
	Subsoil	...	...	...	...	...	**1**	**1**	**2**	...	...	...	...	...	...	...	...	...	...	..	..	..	...	...	...	...	...	...	...	...	...	...
Esperance ...	Surface	25·74	...	...	...	...	...	...	...	...	1	3	9	3	1	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	Subsoil	...	...	...	...	...	...	...	...	...	**1**	...	...	**1**	**1**	**1**	**2**	**1**	...	**1**	...	...	...	...	...	...	...	...	...	...	...	...

* Records from stations along the No. 1 Rabbit Proof Fence. As these stations were visited but monthly these figures are undoubtedly low.

Having treated the results statistically it seems appropriate to give details concerning certain of the type samples.

Table 3 gives details of the reactions of the profiles of soils of the mallee type.

TABLE 3.—REACTION OF THE LAYERS OF THE PROFILES OF SOILS OF THE MALLEE TYPE.

Merredin. Rainfall 13·18 inches.		Salmon Gums District. Rainfall 12·75 inches.										Fitzgerald Peaks District. Rainfall unknown—Estimated 12 inches.								Lake King. Rainfall—Estimated 12in.	
Sample No. 79.		Sample No. 46.		Sample No. 47.		Sample No. 48.		Sample No. 49.		Sample No. 50.		Sample No. 63.		Sample No. 64.		Sample No. 65.		Sample No. 66.		Sample No. 89.	
Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.	Depth.	pH.
inches.		inches.		inches.		inches.		inches.		inches.		inches.		inches.		inches.		inches.		inches.	
0—4	6·29	0—3	7·60	0—7	7·05	0—7	7·22	0—6	8·05	0—3	7·02	0—9	7·61	0—3	7·29	0—6	7·86	0—9	7·38	0—4	7·37
4—12	7·19	3—6	7·60	7—15	8·00	8—16	7·94	6—24	8·33	3—10	8·02	9—11	6·19	3—15	8·42	6—27	7·91	9—21	8·16	4—10	8·38
12—18	7·91	6—22	7·86	15—30	8·08	16—36	7·92	24—28	8·21	10—31	8·12	11—21	6·58	15—30	8·45	27—39	8·15	21—30	8·16	10—30	8·54
16—28	8·31	22—42	7·81	30—36	8·05	...	...	...	...	31—48	6·71	...	...	...	...	...	...	...	...	30—48	8·51
28—42	8·38	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	Below 48	8·23

Table 4 shows the nature of the profile of a podsol formed under conditions of high rainfall.

TABLE 4.—REACTIONS OF THE LAYERS OF A PODSOL FROM NORNALUP.

Rainfall Average, 54·11 inches per annum.

SAMPLE 78.

Depth.	Soil.	pH.
Inches.		
0– 4	Peaty sand	4·62
4–15	Grey sand and humus	4·50
15–25	Leached coarse grey sand	5·85*
25–30	Incipient humus pan	5·06
30–36	Coarse grey sand	5·35†

* This sample was analysed in quadruplicate owing to the difficulty of getting agreement in the determinations. The readings varied from 220 to 278 millivolts.

† A similar difficulty was experienced, the voltages varying from 188 to 232 millivolts. No explanation can be offered for these irregularities. No "drift" occurred during the reading of the samples.

Table 5 presents the results from certain "anomalous" scrub plain soils South of Lake King.

TABLE 5.—REACTIONS OF HEAVY CLAY SOILS CARRYING LOW SCRUB WITH OR WITHOUT LOW MALLEE, LYING TO THE SOUTH-EAST OF LAKE KING.

The Rainfall is estimated to be about 15 inches per annum.

SAMPLE No. 91.

Depth.	Soil.	pH.
Inches.		
0– 3	Brown loam with quartz and laterite pebbles on surface	7·5
3–12	Pale brown clay	8·5
12–18	Chalky clay	8·5
18–24	Grey clay	8·4

SAMPLE No. 93.

Depth.	Soil.	pH.
Inches.		
0– 5	Brown sand	7·0
5–12	Pale brown clay	8·4
12–22	Brown clay with limestone rubble	8·5
22–25	Tenacious dark brown mottled clay	8·4

SAMPLE No. 94.

Depth.	Soil.	pH.
Inches.		
0– 6	Brown sand	6·9
6–12	Mottled yellow brown clay	6·4
12–18	Yellow clay with limestone rubble on gravel	8·3

Discussion of Results.

1. *The laterites.*—The formation of laterites is receiving considerable attention in Australia at present both from geologists and soil chemists, and it is hoped that, as a result of the thought and discussions on the subject, a clear understanding of them as an agricultural problem will be obtained. It is recognised that Western Australia is most vitally interested, as the occurrence of this geological formation is very much more extensive in the western than in the eastern portion of the continent. It is recognised, too, that the most important and pressing fertility problems in Western Australia are associated with the laterite formations, and their attack and solution depends largely on the understanding of the nature of this type. It is the opinion in certain quarters that laterisation of rock materials is not proceeding at present in the southern portion of Western Australia, it being held that the laterites at present exposed are "fossil" soils, the relics of a pre-historic climate, presumably of high and intermittent rainfall associated with high temperatures. While there is much opinion against this theory it seems highly tenable to many soil chemists and is being used as a very useful "hypothesis" at present.

Strong support for this hypothesis is afforded by the work of Martin and Doyne in Sierra Leone, West Africa (1927, 1930), where laterite is actually forming *in situ* from basic rocks under the present climatic conditions of 150 to 180 inches of rainfall per annum and tropical temperatures. The significant feature of their findings in connection with the discussion in this paper is the fact that these basic rocks are yielding a soil with a reaction ranging from pH 4.5 to pH 5.5, the surface being the more acid. In Western Australia we find lateritic soils under most climatic conditions and, as far as the investigation has proceeded to date, it is found that these soils are uniformly acid, independent of present climate. It seems reasonable to postulate that this condition of acidity is the impress of another epoch; is the result of soil formation under entirely different climatic conditions from those operating at present. This idea receives very strong support from the fact that contiguous soils, formed directly from granites, basic or sedimentary rocks, show a response to the present climate in the formation of mallee soils, brown earth, or podsols according to the conditions. Laterite soils or lateritic materials are found overlying these same rocks in the same districts. A study of Tables 1 and 2 will reveal the evidence obtained in support of this argument.

2. *The "normal" soils.*—This term is used advisedly and includes those types which fit in with the zonal system of soil classification as suggested by Prescott. The mallee, brown earth, and podsol types are regarded as typically "normal" soils, being formed directly from recognised igneous or sedimentary rocks. The profile and reaction of these soils are distinctly related to the climate. The correlation between reaction and rainfall in particular is well illustrated by distribution Table 1. It is seen that the soils are alkaline under low rainfall conditions and become progressively more acidic with increased rainfall conditions, the extremes being the mallee soils under a 10 to 15 inch annual rainfall and the podsols of the South-West under 40 to 50 inch annual rainfall. Other soils, particularly those from certain districts of the South-West, have been difficult to place, but for convenience are included in this group in the absence of more complete information.

The several types are discussed in some details below.

a.—*The mallee types.*

The term mallee type is here used to include all normal soils formed under a relatively low winter rainfall, ranging from 10 to 15 inches per annum. The soils vary from sands to clays and invariably show an accumulation of calcium carbonate in the subsoil at a depth of from 8 to 20 inches. The calcium carbonate may occur in a chalky form or as small or large nodules of travertine. Occasionally it occurs as a sheet of travertine 8 to 10 inches below the surface. Under certain conditions there may be calcium carbonate even in the surface layers, either in the finely divided form or as nodules.

The vegetation varies from mallee scrub to large timber such as salmon gum (Eucalyptus salmonophloia), gimlet (Euc. salubris), and morrel (Euc. longicornis, Euc. oleosa, and Euc. melanoxylon). The Eastern wheat belt of Western Australia is entirely within the zone of the mallee soil type, and these soils are known to be very productive under favourable rainfall conditions and suitable management.

The reaction of the mallee soils is on the alkaline side with a mean in the neighbourhood of pH 8. The A horizon, often 3 to 4 inches in the heavier textured soils and as deep as 12 or 15 inches in light textured soils, is usually slightly acid, while the subsoil, in this case the B2 horizon, is invariably more alkaline. When a definite C horizon is reached it is sometimes found to be distinctly acid. See Tables 1 and 3.

b.—*The brown earth types.*

These soils are formed under conditions of higher rainfall and are found in districts with rainfalls ranging from 15 inches to about 25 inches. These soils are less alkaline than the mallee type and appear to range in reaction from pH 6.0 to pH 7.5. Exceptions occur, but sufficient evidence has not yet been accumulated to explain them, or to evaluate their significance. To this group belong the best lands of the Great Southern districts, the Northampton and Chapman districts, the Northam, York, and Toodyay districts, and probably part of the Midland districts.

c.—*The soils of the South-West.*

Reference to Table 1 will show that the soils of the South-West are on the acid side. In general they are podsols or podsolised. No complete discussion can be attempted at present as these soils are formed from laterites, igneous rocks, and transported materials, and sufficient study has not yet been made to attempt even a rough classification or separation of the major soil types. It appears that, whether the material concerned is igneous or lateritic, podsolisation or severe leaching is taking place, and soils relatively low in mineral plant foods predominate.

An interesting soil type of the South-Western districts is the marsh or coastal swamp. Marshes appear to occur along the coast Southward from Gingin. They are often but a few feet above sea level, are acid in reaction, and require drainage. A peculiar feature is the intense acidity of the deeper subsoils, reactions as low as pH 2.8 being recorded for subsoils from

Capel. This acidity has been explained by Dr. E. S. Simpson, Government Analyst and Mineralogist, as being due to sulphuric acid formed by the oxidation of marcasite which occurs in the deeper subsoils.

d.—*The solonetz or leached alkali soils.*

Evidences of soils being leached with solutions containing sodium salts are obtained from various parts of the State. Samples were obtained from a casuarina glauca flat at Moora and on analysis it was found that the soil was slightly acid. The surface soil (0-4in.) was a grey sandy loam and the subsoil (4-8in.) a very tough, grey hard pan. Studies on the nature of the replaceable bases of these soils are needed before any discussion can be indulged in.

e.—*The rendzina soils.*

Under certain conditions limestones or chalks weather to form a lime-humus or rendzina soil—a black clay, rich in humus. These soils occur on the Gingin chalks of Gingin and Dandarragan and, probably, near Dongarra. They are pasture soils, treeless in the virgin condition, and are noted for the fattening quality of the feed produced. They are alkaline soils occurring under climatic conditions which are conducive to the formation of soils of an acid reaction.

f.—*"Anomalous" scrub plain soils.*

Soils bearing scrub in the part of Western Australia under consideration are expected to be either sandy or gravelly. Exceptions were found in the area south of Lake King and at Mt. Madden. At these places poor, low scrub was found on relatively heavy clay soils with calcareous subsoils—soils which would be expected to carry mallee or timber. No explanation can at present be offered, but efforts will be made to obtain evidence with a view to ascertaining the controlling factors responsible for the absence of timber. A knowledge of these factors should be of great value in devising the most suitable management for scrub plain soils.

From the details presented and discussed it is hoped that the foundations may be laid for a systematic and scientific study of our soils which present so many interesting economic and scientific problems. It is believed that, as the body of exact information accumulates along these lines, more and more accurate advice will be available for the benefit of the agriculturalist in particular and the country in general. In view of the demand for lower production costs, it seems pertinent to offer the methods of science as an invaluable adjunct to the efforts of the primary producer, being confident that these will be as effective in agricultural practice as in industrial developments.

Summary.

The paper deals with the results of the study of the reaction of a large number of soil samples collected to represent typical soils in the Southern part of Western Australia.

The results are expressed in two distribution tables and three ordinary tables. The geographical positions of the localities sampled are indicated on a map.

The reactions were determined by means of the quinhydrone electrode.

The following conclusions are suggested from a study of the results:—

1. Two classes of soils occur in the area investigated—
   (a.) the lateritic soils now being formed from laterites;
   (b) "normal" soils forming by direct weathering of igneous or sedimentary rocks.

2. The lateritic soils are almost invariably acid in reaction, the reaction showing no correlation with the rainfall or other climatic factor.

3. The laterites have formed under entirely different climatic conditions from those now operating and may be regarded as fossil soils.

4. The "normal" soils show a very close correlation between soil reaction, soil profile, and climate as measured by the rainfall factor.

5. The normal soils studied fall into three main zonal types—
   (a) Mallee—alkaline soils formed under conditions of low rainfall ranging from 10 to 15 inches.
   (b) Brown earths—slightly acid to slightly alkaline soils formed under conditions of higher rainfall, ranging from 14 inches to about 25 inches.
   (c) Podsols forming under conditions of high rainfall, ranging from about 20 inches upwards. These soils are distinctly acid in reaction.

6. A study of the distribution table shows that alkaline soils normally form under conditions of low rainfall and that soils become progressively more acidic in character as the rainfall increases until the highly leached, acidic podsol is obtained under high rainfall conditions.

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WESTERN AUSTRALIA

Map showing Railways ++++++++++
principal towns and places
from which Soil Samples have
been collected for this Study

0 — 60 mls
Reference

115° 116° 117° 118° 119° 120° 121° 122° 123°

28° 29° 30° 31° 32° 33° 34° 35°

Ajana
Northampton
Yuna
Mt. Magnet
Mullewa
Indarra
Geraldton
Mendel
Greenough
Dongarra
Mingenew
Morawa
Perenjori
Dampawah
Three Springs
Walkaroo
Dalwallinu
Kalannie
Kulja
Moora
Miling
Koorda
Wongan Hills
Lake Brown
Campion
Bullfinch
Wyalcatchem
Kununoppin
Southern Cross
Goomalling
Merredin
Gingin
Toodyay
Northam
Kellerberrin
Rabbit Proof Fence No 2
Rabbit Proof Fence No 1
PERTH
Fremantle
Spearwood
York
Quairading
Bruce Rock
Beverley
Narembeen
Brookton
Corrigin
Pingelly
Kondinin
East Karlgarin
Pinjarra
Narrogin
Lake Biddy
Newdegate
Lake Grace
Wagin
Bunbury
Brunswick
Busselton
Capel
Ludlow
Katanning
Pingrup
Nannup
Bridgetown
Manjimup
Pemberton
Tambellup
Gnowangerup
Ongerup
Stirling Range
Mt. Barker
Porongorups
Kornalup
Denmark
Albany
Hopetoun
Ravensthorpe
Esperance
Glenelg Hills
Mt Holland
Emu Rock
Forrestania
Lake Carmody
3500 Farms Scheme
Mt Gibb
Lake King
Mt Madden
Kalgoorlie
Coolgardie
Widgemooltha
Norseman
Fitzgerald Peaks
Salmon Gums
Grass Patch
Scaddan
Rabbit Proof Fence

LIST OF PUBLICATIONS

of the

ROYAL SOCIETY OF WESTERN AUSTRALIA.

With Names of **Authors** *and short titles of Papers.*

JOURNALS AND PROCEEDINGS.

Vol. I., 1914–1915.—**M. A. Browne**—Approximate summation of series. **W. B. Alexander**—A new stomatopod—Further notes on stomatopods—History of zoology in W.A., part II.—Birds met by Vlaming on the Swan River. **W. J. Dakin**—Marine biology in W.A.—Vitalism in modern biology. **H. B. Curlewis** Tides. **E. S. Simpson** - Natrojarosite from Kundip—**W. D. Campbell**—Natives of Sunday Island. **C. Hedley**—Preliminary index of mollusca of W.A.

Vol. II., 1915–1916.—**A. Gibb Maitland**—Problems of Western Australian geology. **F. E. Allum**—Principles of currency. **J. T. Jutson** and **E. S. Simpson**—Geology and physiography of Albany. **A. Montgomery**—Physiographical characteristics of Western Australia. **W. B. Alexander**—Orthopterous insects from W.A.—A new species of *Evoxymetopon*.

Vol. III., 1916–1917.—**W. J. Hancock**—X-rays. **W. B. Alexander**—History of zoology in W.A., Part III. **H. W. V. Talbot** and **E. de C. Clarke**—Expedition to South Australian border. **A. D. Ross**—Gyrostatic action. **W. V. Fitzgerald**—Botany of Kimberleys.

Vol. IV., 1917–1918.—**A. Montgomery**—Closer application of science to industries. **F. E. Allum**—Decimalisation of British currency. **W. B. Alexander**—New species of marsupial. **W. J. Dakin**—W.A. pitcher plant.

Vol. V., 1918–1919.—**W. J. Hancock**—Science and civilisation. **W. G. Woolnough**—Physiographic elements of Swan coastal plain. **J. S. Battye**—Causes of colonisation of W.A. **W. Kingsmill**—Acclimatisation. **W. A. Saw**—Town-planning. **A. R. L. Wright**—Houses in W.A. **D. A. Herbert**—The W.A. Christmas tree. **A. D. Ross**—Light and the ether. **E. S. Simpson**—Hisingerite.

Vol. VI., Part I., 1919–1920.—**J. L. Somerville**—Uplift in neighbourhood of Perth. **W. B. Alexander**—W.A. Lampreys—Aboriginal names of animals—(With **C. E. Lane-Poole** and **D. A. Herbert**) Indigenous plants of economic importance. **D. A. Herbert**—Climbing a waterfall by lampreys—*Xanthorrhoea reflexa*. **E. de C. Clarke**—Glaciated boulders near Leonora and Laverton. **E. Cheel**—New species of *Daviesia*.

Vol. VI., Part II., 1919–1920.—**G. L. Sutton**—Science and Agriculture—Absorption of moisture by wheat. **D. A. Herbert**—Confusion between *Acacia cyanophylla A. seligna* and *A. cyclopis*—Contributions to flora of W.A. No. 1 *Proteaceae Rutaceae Polyporaceae Phalloideae*. **E. S. Simpson**—Cobaltiferous Epsomite. **S. K. Montgomery**—*Hymenosomidae* from Swan River. **J. Clark**—W.A. Ant-nest beetles. **E. Ashby**—Three species of *Stenochiton* from W.A.

Vol. VII., 1920–1921.—**E. S. Simpson**—Science and mineral industry—Staurolite from Mogumber. **L. Glauert**—W.A. Petrels and Albatrosses—Fish collected near Albany—Pleistocene fossil vertebrates from Fitzroy River—Teeth of *Nototherium mitchelli*. **M. Aurosseau** and **E. A. Budge**—Terraces of Swan and Helena Rivers. **H. Bowley**—Chemistry of alunite. **D. A. Herbert**—Contributions to flora of W.A., Nos. 2 and 3—Parasitism of the Quandong—Parasitism of the Sandalwood—*Xanthorrhoea* in W.A. **G. E. Nicholls**—*Dero roseola (naidiform worm)*. **W. E. Shelton**—Xerophytism in Swan River district.

Vol. VIII., 1921–1922.—**F. E. Allum**—Modern currency problems. **G. L. Sutton**—Pedigree selection of wheat. **L. Glauert**—Contributions to Fauna of W.A., No. 1. **E. Ashby**—*Acanthopleura*. **D. A. Herbert**—Contributions to Flora of W.A., No. 4. **A. Cayzer** and **F. W. Wakefield**—*Darwinia pimelioides*. **R. D. Thompson** -Solar eclipse of September 21, 1922.

Vol. IX., Part I., 1922–1923.—**R. A. Farquharson**—Impsonite in W.A.—Geology of Kalgoorlie. **C. A. Gardner**—Contributions to Flora of W.A., Nos. 1 and 2. **J. Clark**—New myrmecophilous beetle—Honey ants. **L. Glauert**—Cretaceous Echinid—Contributions to Fauna of W.A., Nos. 2 and 3. **R. J. Tillyard**—Embioptera of W.A.

Vol. IX., Part II., 1923.—**E. de C. Clarke**—Pre-Cambrian in W.A. **R. Trumpler**—Structure of Sidereal Universe. **E. S. Simpson**—Secondary sulphates and chert in Nullagine Series. **T. H. Withers**—Cretaceous cirripede. **A. D. Ross** and **R. D. Thompson**—Energy involved in recent outburst of Beta Ceti. **E. O. G. Shann**—Foreign Exchange. **J. Clark**—Australian Formicidae. **C. A. Gardner**—Contributions to Flora of W.A., No. 3. **L. W. Phillips**—Essential oils of some W.A. plants.

VOL. X., 1923-1924.—**W. H. Shields**—Sand Bars. **E. Cheel**—New myrtaceous plant. **L. Glauert**—Fossil plants from Mingenew and Irwin River—*Phreatoicus palustris*—Contributions to Fauna of W.A., No. 5. **E. Ashby**—New species of *Acanthochiton*. **A. D. Ross**—Einstein eclipse tests—Theories regarding the Æther. **G. E. Nicholls** and **D. F. Milner**—*Hyperoedesipus plumosus*. **G. E. Nicholls**—*Phreatoicus lintoni*—*Neoniphargus branchialis*. **W. E. Wood**—Increase of salt in soil and streams. **E. S. Simpson**—Goongarrite. **W. M. Carne** and **E. J. Limbourn**—Natural crossbreds in oats and barley. **J. Clark**—Australian Formicidae. **C. A. Gardner**—The so-called *Ericopsis formosus*.

VOL. XI., 1924-1925.—**F. W. Whitehouse**—Jurassic fossils from Western Australia. **T. H. Withers**—*Uintacrinus* in Australia. **C. A. Gardner**—New species of *Darwinia*—Naturalised plants of extra-tropical Western Australia. **A. Knapp**—Actinic value of light. **D. W. Everson**—Crystal receiving sets. **J. L. Reath**—Mollusca from sub-recent beds of Swan River. **W. M. Carne**—Census of plant diseases of South-Western Australia. **Chas. Chilton**—A new species of *Neoniphargus* from Western Australia. **E. Cheel**—"Blind Grass." **L. Glauert**—Australian *Scorpionidea*, Part I. **E. S. Simpson**—Japan. **A. D. Ross**—Variation of light intensity of corona—Science and Industry. **D. A. Herbert**—Root parasitism of Western Australian *Santalaceae*.

VOL. XII., 1925-1926.—**R. J. Tillyard**—New spoon-winged lace-wing. **L. Glauert**—Gingin Chalk. **W. M. Carne**—Brown rot of citrus. **J. Clark**—Australian *Formicidae*. **L. F. Spath**—Ammonites from Gingin. **E. S. Simpson**—Contributions to W.A. mineralogy, Series i. **C. A. Gardner**—Contributions to flora of W.A., No. 5. **G. E. Nicholls**—*Protocrangonyx fontinalis*—*Neoniphargus obrieni*—New genus and species of Amphipods - *Uroctena yellandi*—New genera and species of Phreatoicidea. **G. E. Nicholls** and **H. M. Barnes**—*Haloniscus stepheni*—Two new terrestrial isopods. **G. E. Nicholls** and **K. C. Richardson**—New species of *Acrotelsa*. **G. E. Nicholls** and **A. A. Jackson**—New species of *Megascolex*. **T. H. Withers**—*Marsupites* and a new cirripede from Upper Cretaceous of W.A. **E. de C. Clarke**—Natural regions in W.A. **E. de C. Clarke** and **F. A. Williams**—Geology and Physiography of parts of Darling Range. **A. Gibb Maitland** - W.A.'s Contribution to Earth History. Brief descriptions of some exhibits.

VOL. XIII., 1926-1927.—**T. H. Maiden** and **W. F. Blakely**—Fifty new species and six new varieties of Western and Northern Australian Acacias. **E. S. Simpson**—Contributions to W.A. Mineralogy, Series ii. **H. W. Bennetts**—Helminths of Western Australian Stock, Series i. **Chas. A. Gardner**—Contributions to flora of W.A., Series vi. **A. D. Ross**—On the evolution of the new star "Nova Pictoris"—The Physical properties of Manganese steel. **A. Gibb Maitland**—Volcanic History of W.A.

VOL. XIV., 1927-1928.—**W. M. Carne**—History of Phytopathology. **A. R. Penfold** - Chemistry of Concrete Otto Boronia. **H. W. Bennetts**—Western Australian Poison Plants. **W. M. Carne**—Plant Diseases of South-Western Australia. **J. Clark**—Australian Formicidae. **E. S. Simpson**—Contributions to W.A. Mineralogy, Series iii. **H. W. Bennetts**—Further Contributions to the Helminths of W.A. Stock. **L. Glauert** Vertebrate Fauna of W.A., Part I. **C. A. Gardner**—Contributions to Flora of W.A., Series vii.

VOL. XV., 1928-1929.—**R. S. Rogers**—A new genus of Australian Orchid. **D. Rotenberg**—Male generative apparatus of *Tarsipes spenserae*. **L. Glauert**—Habits of *Tarsipes spenserae*. **A. G. Nicholls**—New species of Termite. **D. F. Milner**—Two new species of *Anostracan Phyllopoda*. **L. Glauert**—Contributions to Fauna of Rottnest Island, No. 1, Introduction and Vertebrates. **E. Ashby**—Contributions to Fauna of Rottnest Island, No 2 *Polyplacophora*. **J. Clark**—Contributions to the Fauna of Rottnest Island, No. 3, The ants. **K. J. Finucane** and **F. G. Forman**—Observation on the load carried by the Swan River during the 1926 flood. **D. L. Serventy**—Records of *Cladocera* from the South-West Province of Australia. **H. A. Pittman**—Morphology and Endotrophic Mycorhiza of *Rhizanthella Gardneri* and other Western Australian Orchids. **J. W. Audas** and **P. F. Morris**—A new species of *Persoonia* from Western Australia. **J. W. Audas**—Botanical activities of *Max Koch*. **B. C. Cotton**—Contributions to Fauna of Rottnest Island, No. 4—*Sepudae*. **C. F. Roewer**—Contributions to Fauna of Rottnest Island, No. 5—*Opiliones*. **E. S. Simpson**—Contributions to the Mineralogy of Western Australia, Series iv. **L. J. H. Teakle**—Water Extracts of Western Australian Soils, No. 1—Studies on soils from Merredin, Ghooli, Salmon Gums, Wongan Hills, Chapman, Baker's Hill and Lake Brown.

INFORMATION REGARDING COMMUNICATIONS TO THE SOCIETY AND INSTRUCTIONS TO AUTHORS OF PAPERS PRESENTED FOR PUBLICATION.

1.—Communications.

Communications to the Society at its General Meetings take the form of Papers, Notes, Demonstrations, Lectures, or Contributions to Special Discussions.

2.—Publications.

Communications announcing the results of original research, or collecting important information not easily accessible, or otherwise of special value to Western Australia, may be printed in the "Journal" in a form approved by the Society's Publication Committee.

3.—Reading of Papers.

At meetings of the Society, papers may be announced for reading *in extenso,* in part, or (in cases of highly technical papers to be printed in the "Journal") only by title. In general, authors will find that the brief and concise statement which is the best form of paper for publication is unsuitable for verbatim reading at the meeting.

In order to secure adequate discussion at the meeting, and also to expedite publication, papers should be submitted in advance, as required by the Rules of the Society.

4.—Manuscript.

Papers should be written in the third person, as clear and concise as possible, and in a form suitable for publication and complete when communicated to the Society.

The copy of a paper intended for publication should be written on large sheets of paper, on one side only; the lines should be widely spaced, and the pages clearly numbered. The MS. must be easily legible, preferably typewritten in double spaced typescript on sheets of ordinary thickness, uniform in size, and must be absolutely in its final form for printing; the copy should be carefully corrected by the Author before it is presented. In order to give room for editorial marking, etc., it is desirable to leave a margin of at least an inch at the top of the page, an inch at the left, and not less than half an inch at the bottom.

Drawings or photographs intended for use as illustrations should be kept distinct from the text, not inserted in it, though transmitted at the same time. All references to plates or illustrations in the text, etc., must be in their proper places, and the spaces indicated for the insertion of illustrations which are to appear in the text.

5.—Illustrations.

All illustrations must be in a form immediately suitable for direct photographic reproduction. As the single page printed plate will not exceed 8 inches in length by 4¼ inches in width, drawings may be of this size, or a convenient multiple of this, in order to facilitate reduction. Plates which are to be folded may exceed the above limits, but must in all cases

be a convenient multiple thereof. Text figures should be drawn for reduction to a width not exceeding that of the text page (8 inches by 4¼ inches) and at least a quarter of an inch shorter. Drawings to be reproduced as line blocks should be made with Indian ink, preferably on fine white bristol board, free from folds or creases; smooth, clean lines, or sharp dots, but no washes or colours should be used. If the drawings are made on a large scale, to be afterwards reduced by photography, any lettering or other legend must be adapted to the reduction in scale. When reduction in a definite ratio is required, this must be clearly and specifically stated on the drawing. Where illustrations are numerous, much time would be saved if Authors would indicate in advance those considered essential to the understanding of their papers. The Editor will be pleased to give advice to Authors as to the preparation of their illustrations.

6.—ADDITIONS.

Additions to a paper, on acceptance by the Publication Committee, shall, after it has been finally handed in for publication, be treated and dated as a separate communication, and may, or may not, be printed immediately after the original paper.

7.—PRINTING.

As soon as any paper has been accepted for publication, either in its original or in any altered form, it is sent to the printer in accordance with the Council's revised instructions as to the printing of papers.

8.—PROOFS.

A first proof and, if necessary, a revise proof will be sent to the author, whose address should be indicated on the MS. No corrections other than literals may be made without the express sanction of the Editor, and where alterations other than those of printer's errors are allowed, the cost shall be borne by the Author. The Editor may at his discretion proceed with the printing of the paper, if the proofs are not returned by the Author within one week from the date of issue, and in such case neither the Society nor any of its officers shall be responsible for any uncorrected errors in the printing. Authors of papers who live at a considerable distance from Perth should authorise someone in the metropolitan area to revise their proofs.

9.—AUTHOR'S COPIES.

Authors receive gratis 30 copies of their paper and, at cost price, any additional number required, provided that the number of copies required is intimated to the Editor as soon as the paper is accepted for publication.

Rules

OF

The Royal Society of Western Australia.

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Rules

OF

The Royal Society of Western Australia.

THE ROYAL SOCIETY OF WESTERN AUSTRALIA.

CONSTITUTION.

1. The Society shall be called the Royal Society of Western Australia.

2. The Royal Society of Western Australia is founded for the advancement of science in all its branches.

3. The Society shall consist of members, who shall be classed as follows: (1) ordinary members (who may be life members); (2) honorary members; (3) corresponding members; (4) associate members; (5) student members.

RULES.

MANAGEMENT.

1. The General Management of the affairs of the Society, together with the custody of its property, shall be vested in a Council, comprising a President, two Vice-Presidents, a Treasurer, a Secretary (or Secretaries), a Librarian, an Assistant Librarian, the retiring President and eight other members.

2. All office bearers and general members of the Council shall be elected annually by ballot at the General Meeting of the Society, held in July.

3. The Council shall submit to the General Meeting in June each year a list containing the names of members nominated by the Council for election for the ensuing session to the respective offices of President, Vice-Presidents, Secretary (or Secretaries), Treasurer, Librarian and Assistant Librarian. The Meeting shall then proceed to nominate members for election as General Members of the Council, and may nominate further candidates for offices. Additional nominations, if duly seconded, may be lodged with the Secretary (or Secretaries) within seven days after the June meeting.

4. If the number of nominations for each position does not exceed the number of vacancies, the Chairman at the Annual General Meeting shall declare the persons whose names appear on the list duly elected. If the number of nominations for any office exceeds the number of vacancies, a ballot shall be taken. A ballot paper containing the names of all persons thus nominated shall be posted to members at least fourteen days prior to the day of the Annual General Meeting. Members shall hand in their ballot papers, duly filled up but unsigned, to the Secretary (or Secretaries) at the

Annual General Meeting or shall post them to the Secretary (or Secretaries) so as to be received not later than the commencement of the Meeting. Scrutineers shall be appointed at the Meeting, and shall announce thereto the result of the ballot.

5. Any vacancies occurring amongst the office bearers or Council during the year shall be filled up by the Council.

6. The Council shall define the duties of the Secretary (or Secretaries) and may add any distinguishing word to the title in accordance with the nature of the duties.

MEMBERS.

7. Every candidate for admission as an ordinary member of the Society shall be proposed and recommended by three or more members of the Society, who shall, at an ordinary meeting of the Society, cause to be delivered to the Secretary (or Secretaries) a nomination form, signed by themselves, signifying the name, description and usual place of residence of such person, who must be known personally to at least one of the recommending members.

8. Every nomination form having been read at one of the ordinary general meetings shall be posted in some common room of the Society, and the person thus recommended shall be balloted for at the next ordinary general meeting after such reading.

9. No person shall be declared duly elected unless three-fourths of the number of members balloting shall vote in his favour.

10. Persons so elected shall have immediate notice thereof transmitted to them by the Secretary (or Secretaries) accompanied by a copy of the Rules.

11. No candidate shall be deemed a member until his subscription for the current year is paid or the annual payments be compounded for. If any person elected as a member shall omit to pay the subscription (or composition in lieu thereof) within six months after the day of election, the Council shall have authority or declare such election void.

12. The annual subscription of every ordinary member shall be One Guinea, and the composition fee for life membership £15 15s.

13. The annual subscription becomes due on the 1st July in every year, in advance, and is recoverable as debt due from the member to the Society. If any member shall be in arrears of his annual contribution for two years on the day of any Annual Meeting, he shall be apprised by letter that unless the amount due by him be paid before the end of the current month his name will be removed from the list of members.

14. All members elected at any time during the latter six months of the financial year shall pay half the annual subscription appertaining to the class to which each is elected, for the then current year.

WITHDRAWAL AND REMOVAL OF MEMBERS.

15. No member shall be at liberty to withdraw from the Society without previously giving notice in writing to the Secretary (or Secretaries) of his intention to withdraw, and returning all books and other property of

the Society in his possession. Retiring members shall be liable for payment of all subscriptions due to the Society.

16. The Council may, by a majority of 7 of its members, remove or suspend any member of the Society, with or without assigning reasons for such action. But a member whose name has been removed from the Roll shall have a right of appeal to the Society. Notice of such appeal to the Society shall be sent by such member to the Secretary (or Secretaries) within four weeks of the removal of his name, and the appeal shall be considered by the Society at the next General or Special Meeting, a majority of votes recorded at such meeting sufficing to confirm or annul the decision of the Council.

PRIVILEGES OF MEMBERS.

17. Ordinary members have the right to be present and to vote at all General Meetings; to be eligible for election to a seat on the Council, to submit papers to the Council for communication to the Society and subsequent publication if approved by the Council; to communicate papers dealing with subjects connected with Western Australia on behalf of authors not resident in the State; to be entitled to receive the publications of the Society; to propose candidates for admission as ordinary and associated members; and subject to the approval of the Librarian, to borrow any books, papers, manuscript, etc., belonging to the Society.

18. Ordinary members may introduce one visitor at any meeting, provided such visitor is not introduced at more than three meetings in one year.

ASSOCIATE AND STUDENT MEMBERS.

19. Associate members shall have all the privileges of ordinary members, with the exception that they shall not have the right of voting, nor of eligibility for office, nor of proposing new members. They shall pay an annual subscription of half a guinea. They may receive one copy of the Journal.

20. Student members shall be persons under the age of 22 attending recognised science classes in Western Australia, who shall, on application to the Council, be elected by them. They shall be elected for a period of twelve months only and shall pay a subscription of 5s. Student members shall not be entitled to any privileges, except that of attending the meetings of the Society.

HONORARY MEMBERS.

21. The honorary members of the Society shall be distinguished workers in science or zealous patrons thereof, and shall not exceed 25 in number.

22. Every person proposed as an honorary member shall be recommended by Council, and be elected and removed in the like form and manner, and be subject to the same rules and restrictions as ordinary members. He shall be entitled to all the privileges of membership except voting.

CORRESPONDING MEMBERS.

23. The corresponding members of the Society shall be constituted of such persons not resident in Western Australia as may show a willingness

to promote the objects of the Society, and shall be recommended and elected and be liable to be removed in like form and manner as ordinary members. The corresponding members shall be exempt from paying any subscription.

24. In case of corresponding members taking up their residence in Western Australia, their privileges shall cease at the end of the current financial year. Any such corresponding member shall have the privilege of becoming an ordinary member, without ballot, on paying subscription or composition fee.

25. The corresponding members of the Society are required to keep the Secretary (or Secretaries) informed of their addresses, or of that of some agent in Western Australia, through whom communications may reach them.

PRESIDENT AND VICE-PRESIDENTS.

26. The duties of the President shall be to preside at all meetings of the Society and Council, and regulate all the proceedings therein; and generally to execute or see to the execution of the Rules and Orders of the Society. In the case of an equality of votes the President shall have the casting vote.

27. In case of the absence of the President from any of the meetings of the Society or Council, his place shall be filled by one of the Vice-Presidents, or, in their absence, by a member of the Council then present, who shall, for the time being, have all the authority, privileges and power of the President. If no member of the Council should be present at an Ordinary Meeting no business shall be transacted.

TREASURER AND ACCOUNTS.

28. The Treasurer shall demand and receive for the use of the Society all money due or payable to the Society, and shall disburse all sums due by the Society, and shall keep full and particular account of all sums so received and disbursed.

29. All moneys received on the Society's behalf shall be paid into an account in the name of the Society in a Bank approved by the Council.

30. No moneys shall be drawn out of the said account except by cheque signed by the Treasurer and Secretary (or Secretaries), or any two of them, and all payments must first be authorised by the Council.

31. The accounts shall be made up at the end of every financial year, June 30th, and be audited in the month of July by a committee of two, to be appointed at the ordinary meeting in June.

32. The Auditors shall have the power of calling for a statement of the debts, credits and assets of the Society, and for any information relative thereto.

33. The Committee of Auditors shall make their report to the Society at the Annual General Meeting.

SECRETARY (OR SECRETARIES).

34. The general business of the Society shall be conducted by the Secretary (or Secretaries) in such manner, subject to the direction and approval of the Council, as may be agreed upon.

COUNCIL.

35. The Council shall meet at such times as may be appointed by the President, or in his absence by one of the Vice-Presidents or the Secretary (or Secretaries), due and sufficient notice being previously sent to every member.

36. No business shall be transacted in Council unless there be four or more members present. Should any member fail to attend three consecutive Council meetings without satisfactory reason being given, his position shall be declared vacant.

37. The Council shall present and cause to be read to the Annual General Meeting a report on the general concerns of the Society for the preceding year, and such report shall be printed in the Volume of Proceedings for that year.

ORDINARY GENERAL MEETINGS.

38. The Council may institute and enforce any By-laws necessary for the government of the Society, provided that such are not at variance with these Rules.

39. The General Meetings of the Society shall take place at 8 p.m. on the second Tuesday in every month during the last ten months in every calendar year, unless the Council determines otherwise. Special meetings of the Society may be called by the Council whenever it may deem such expedient, or on the requisition of ten members, in writing, and specifying the purpose for which the meeting is required, sent to the Secretary (or Secretaries), who shall thereupon call a meeting within not less than seven days nor more than twenty-eight days.

40. The ordinary course of proceedings at the General Meetings after the Chair has been taken shall be as follows:—

(1) The minutes of the proceedings of the previous meeting.
(2) Correspondence.
(3) Communications from Council.
(4) Nominations for membership and election of members.
(5) Donations to be laid on the table and acknowledged.
(6) Any other formal or general business to be dealt with.
(7) Lectures, papers, exhibits and discussions thereon.

41. At the Ordinary General Meetings of the Society nothing relating to the regulations or management, except as regards the election of members, shall be brought forward, unless the same shall have been announced in the notice calling the meeting or be otherwise provided for in these Rules.

ANNUAL GENERAL MEETING.

42. The course of Proceedings after the Chair has been taken shall be as follows:—

(1) Reading of the Minutes of the previous Annual Meeting.
(2) Reading of Nominations of Candidates for Council, appointment of Scrutineers, and opening of ballot.
(3) Presentation and discussion of the Auditors' Report.
(4) Presentation and discussion of the Council's Annual Report.

(5) Report of the Scrutineers on the result of the ballot.

(6) President's Address.

43. At the Annual or any General Meeting seven members shall constitute a quorum.

CONTRIBUTIONS TO THE SOCIETY.

44. Every paper intended to be read before the Society, of whatever character, must be sent to the Secretary (or Secretaries) at least seven days before the date of the next ensuing Council meeting, to be laid before the Council. It will be the duty of the Council to decide whether such contribution shall be accepted, or whether it shall be read in full, in abstract, or taken as read. The Council may obtain an opinion from any person it may select on the suitability of any paper for publication.

45. A publication committee, appointed by the Council, shall recommend to the Council whether a paper presented to the Society shall be published in the Proceedings.

46. The original copy of every paper communicated to the Society, with its illustrations, shall become the property of the Society, unless stipulation is made to the contrary, and authors shall not be at liberty to publish their communicated papers elsewhere, prior to their appearance in the publications of the Society, unless permission is given by the Council for so doing.

SOCIETY'S GOLD MEDAL.

47. A Gold Medal shall be awarded by the Council for distinguished work in science connected with Western Australia. The method of making an award shall be as follows:—

(a) Awards shall be made by the Council only on a recommendation by a Medal Committee, and such recommendation shall require to be approved by not less than three-fourths of the members present at the Council meeting.

(b) The Medal Committee shall consist of five members of Council and shall be representative of various branches of science.

(c) Any recommendation by the Medal Committee for the award of the Medal must have the approval of at least four of the five members of the Committee, and shall be accompanied by a statement setting forth the facts on which the recommendation is based.

(d) The Council shall appoint a Medal Committee (i) in the fourth year after any year in which an award has been made, (ii) in each alternate year thereafter until an award is made if an award has not been made as a result of the appointment of a Committee under the previous subsection, and (iii) at such times as the Council may consider it advisable to consider the question of an award to a particular individual, but no Committee shall be appointed under this subsection unless such action is approved by not less than three-fourths of the persons present at a Council meeting of which due notice of such proposed action has been given to each member.

(e) Any Medal Committee which is appointed under these Rules shall report to the Council before the end of the year, and shall then lapse.

FORMATION OF SECTIONS.

48. Sections may be formed for the purpose of any particular branch of science. Any member of the Society may be enrolled as a member of one or more sections. Each section shall appoint a Chairman and Secretary, who shall be approved by the Council. Notice of sectional meetings shall be made on the usual notice card to members. Sections shall not incur expenditure without first obtaining the approval of the Council. Communication to a section may be presented subsequently at a general meeting of the Society.

JOURNAL.

49. (a) The Society shall publish an annual Journal in which papers communicated to the Society during the year may be printed. The Journal and contributions shall be printed in such form as may be decided by the Council.

(b) A copy of the Journal shall be supplied to Ordinary Members and, on application, to Associate Members, in accordance with Rule 15. Student members may receive a copy on payment of 5s. (Ordinary Members may purchase an additional copy at the same price.)

(c) The published price of the Journal shall be fixed by the Council from time to time, but shall not be less than 10s.

(d) Thirty free reprints (with covers) shall be available to authors. The rate at which additional reprints will be supplied to authors will be 4s. per 100 for every four pages, or part thereof. Covers will be charged as four pages.

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